SCIENTIFIC AMERICAN SUPPLEMENT. No. 929

Scientific American Supplement, Vol. XXXVI. No. 929.
Scientific American, established 1845.

NEW YORK, OCTOBER 21, 1893.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

FLOATING BEACONS AND LUMINOUS BUOYS.

THANKS to the progress of modern industry, which makes steam vessels run against wind and tide, swiftly and straight ahead like huge projectiles shot with precision from one world to another, navigation is far from presenting the dangers of former times.

Disasters have diminished in very happy proportions, especially on the high sea, where there is scarcely anything to fear any longer except collisions. Those that are due to storms are exceedingly rare and have

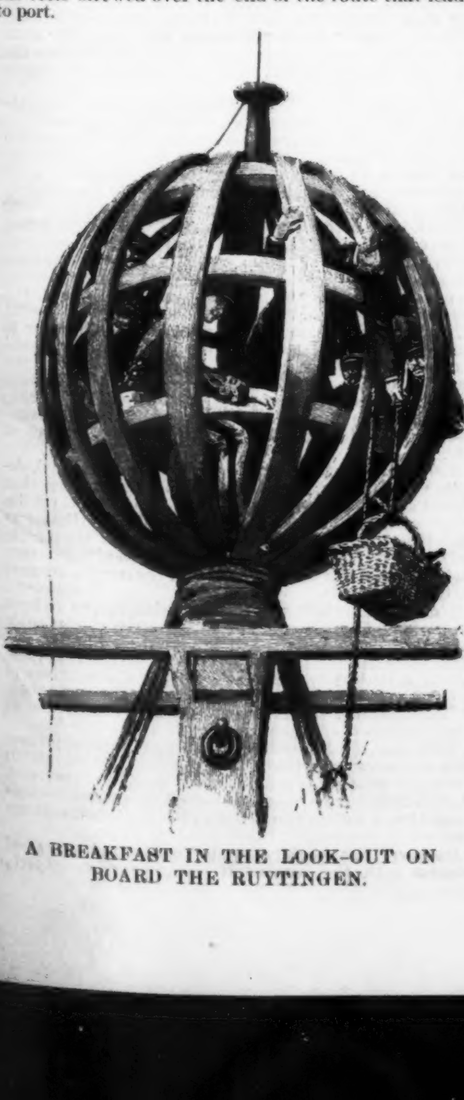
CHANGING THE CREW OF A LIGHTSHIP.

for determining causes the antiquity of the ship or the inexperience of the captain.

The steamers now employed upon the great lines are so powerful and so well endowed with nautical qualities that they superbly get the mastery over the most terrible seas. As for simple stormy weather, no one troubles himself about that. There are fewer people at the table, that's all!

Upon the whole, as long as there is water under the keel, navigation is effected quickly and well. It is of little consequence whether such water be lashed by a contrary or a favorable wind; a few turns of the screw intelligently regulated will re-establish the mean.

The danger, the great and formidable danger, is the earth. The danger lies in the distance remaining to be made by the ship coming from the open sea, having knowledge of the as yet far-distant coast and entering shallow water in the channels, amid treacherous reefs strewed over the end of the route that leads to port.



A BREAKFAST IN THE LOOK-OUT ON BOARD THE RUYTINGEN.

Lighthouses and the indications of semaphores are often too distant to guide the navigator. Sometimes, even, the earth is still hidden by the horizon when the vessel has already run upon perilous bottoms. Hence the extra-urgent necessity of fixed or floating signals determined geographically and marked upon coast maps with their methodical daytime coloration and their method of illumination if they are provided with a focal apparatus.

The lighthouse and buoy service inspires the liveliest interest in all those who occupy themselves with maritime affairs.

It will suffice to mention a few very much frequented port entrances to show what judicious practice and what attentive care is required to bring a vessel to land, and also what installations must be made by engineers to mark out both the day and night route distinctly.

Note that every ship stranded is in a state of wreck. We never know whether the sea will not have changed face in a few hours. It is not necessary that it shall be greatly agitated in order to put the strongest vessel in pieces when it makes use of it for breaking stones!

A small, very gentle swell of a meter strips the ribs out of the colossus that but yesterday confronted the waves of the deep ocean with disdain.

At Dunkirk, between the floating beacon of Ruytingen and the jetties, the route is literally barred by sandbanks, which, for the most part, are never uncovered. It is necessary to adroitly follow sinuous channels in order to avoid them.

At Havre the upper part of the roadstead and the bank of Eclat constitute a true submarine causeway at the entrance of the port. At low tide the Eclat scarcely shows its bad black head. In the southeast the Seine Bay is merely a moving maze of channels intersected by banks of sand and mud, continuously shifted by the violence of the tides.

At Saint Nazaire the same difficulties, caused by the alluvions of the Loire, without speaking of the triple line of reefs that seems to forbid access to the roadstead, from Banche as far as to Pilier; from Pouliguen to St. Michel; from Eve Point to Minden Point.

And the Somme with its *ridins*, and the Adour with its bar! And as for the Gironde, to enter that, it is necessary, if you come from the north, to shun the plateau of Rochebonne, lost to view at more than thirty miles outside of all land. There do not remain three meters of water at low tide, when the sounding lead still shows eighty at a few cable lengths. Then, starting from Cordouan to Pauillac, keep strictly to the channel if you wish to ascend as far as Bordeaux without accident.

The same is the case with our ports of war—with Brest, with Rochefort and with Lorient, where, from the "Chats" of Groix as far as to the "Pengarne," the sea is filled with points and flats.

Marseilles has its Canoubier, its Planier and other very dangerous rocks, now converted into beneficial signals. Finally, Algiers is not without bad places. Does not the Reine-Mathilde reef owe its name to the transatlantic steamer that foundered there within range of the gun of the Admiralty?

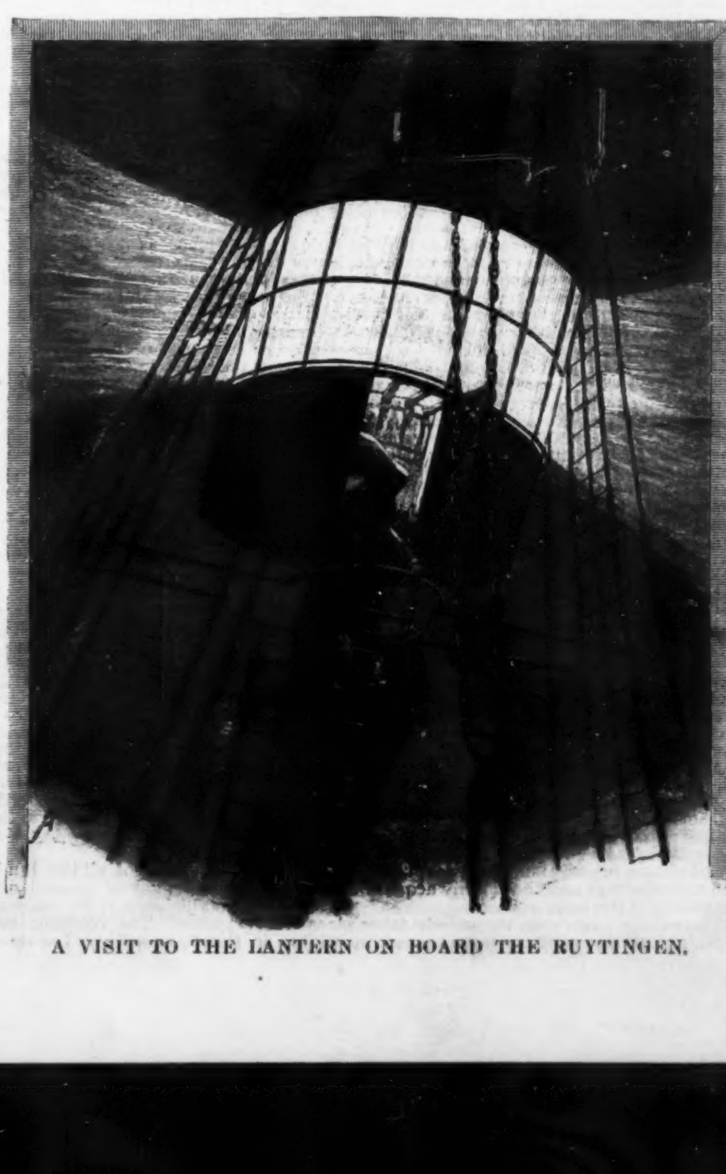
What, then, would become of the navigator in the midst of all this did not science and industry do their best to aid him?

So the question of buoying, and especially of luminous buoying, has made astonishing progress since the solution of the problems that it presented was given by the new metallurgical processes. The maritime nations have gradually installed upon the most difficult points of their coast line fixed beacons, turrets, lightships and simple or luminous buoys giving ma-

A LIGHTSHIP ADRIFT.

riners accurate information as to the route that they must follow in order to make port in all security.

The genius of France always marches at the head of such generous progress. The question of maritime lighting interests us as much to-day as it did two hundred years ago. Colbert made regulations for the light service in the ports and upon vessels; Borda was the first to conceive the practical idea of revolving lights, and the lights of the coast were then no longer confounded with the stars tangent to the horizon; Fres-



A VISIT TO THE LANTERN ON BOARD THE RUYTINGEN.

nel devised the echelon system; and, finally, our modern scientists, engineers, metallurgists and gas fitters have wonderfully improved the floating beacons upon boats or buoys, and have thus permitted of their salutary diffusion in all the seas in the civilized portions of the globe.

The French service of floating beacons was inaugurated in 1860 by the lightships Talais, By and Mapon in the Gironde. There have been installed in succession: the Dyck and Snouw in front of Dunkirk in 1863; the Minquiers in the English Channel and the Rochebonne in the ocean in 1865; the Ruytingen off Dunkirk in 1869; and the Grand-Banc at the entrance of the Gironde in 1870. All these lights, save those of the Ruytingen and Snouw, were white and were hoisted upon strong wooden vessels constructed in the form of a sail-ship. The terrible assaults to which these vessels were subjected rapidly wore upon them. The Dyck and the Ruytingen have already had to be replaced by entirely new boats. All the others, although often thoroughly repaired, are more or less at the end of their race. So the special commission instituted in March, 1892, thinks that there is something better to be done in the interest of navigators and for the wise utilization of the very limited appropriation at the disposal of the beacon service.

Upon the whole, ought we to preserve the lightships, which are costly to establish and maintain, or can they be advantageously replaced by a series of luminous buoys? Such is the question that the commission believes that it is able to solve in requesting the substitution of luminous buoys for six floating beacons. The saving effected will permit of signaling reefs still lost in the night and of thus giving security to numerous mariners who are still awaiting the benefits of the progress upon our coasts of France and Algeria. This advantage alone ought to make the balance lean in favor of the conclusions of the special commission, being admitted, of course, that the points at which duty has already been done by the Snouw, Minquiers, Rochebonne, Talais, By and Mapon will be better than ever determined day and night by the new apparatus.

As soon as it is a question of lightships, it is necessary to expect heavy expenses. They are of undoubted utility in certain localities, as at Ruytingen, for example, but it suffices to pass a few hours on board of the new vessel to see what sacrifices so complete an organization imposes upon the budget of public works.

A floating beacon of this model, put in place and lighted, ought not to cost less than half a million francs.

The new Ruytingen is of steel plate of from 9 to 11 millimeters. It is a true ship measuring 30 meters in length by 7·8 in breadth and 4·12 in depth. Its hull weighs 103,000 kilogrammes, its displacement is 387 tons, while its net gauge does not exceed 235 tons. It draws 3·7 meters aft. Its extreme stability is assured in the first place by its great breadth, then by 90,000 kilogrammes of ballast, and lastly by two strong lateral keels that prevent rolling. It is anchored upon the very bank in 20 meters of water, and is capable, if need be, of moving to a chain length of 300 meters. Its anchors are of an odd shape, and yet are well adapted to the services that they have to render. Imagine an open umbrella or, better, a huge iron mushroom weighing 2,000 kilogrammes. On whatever side it is placed it enters the sand and obtains a firm hold therein. An ordinary anchor would continually drag.

A little in front of the midship beam arises a thick and short mast, well stayed, upon which is hoisted to 12 meters above the horizon the cage that contains the luminous apparatus. This consists of nine lamps arranged in groups of three, with parallel reflectors. The system revolves around the mast and gives a red flash every twenty seconds. The color of the light is obtained through the carmine tint of the glass of the chimneys.

The mast terminates at about 20 meters in a ball formed of hoops of light iron plate painted bright red. Although this sphere appears to be very small, it is nevertheless 6 meters in circumference. We are in a position to assert that ten persons, seated at the equator of this quasi-planet, can sojourn there at their ease and even dine there in a manner as aerial as picturesque.

In order to anticipate cases in which the lightship would have to navigate by its own means (cases extremely rare), it has been provided with a set of sails that permit it to maneuver or sail on a course. There are times, therefore, in which the vessel rises in dignity and becomes a sailing ship. With its big foresail, its staysail and its ringsail, it ought to have an original figure. The hold of the Ruytingen contains not only spacious quarters for the captain and the crew, saloon, cabins, offices, store rooms, coal bunkers, etc., but also the powerful compressed air engine that actuates the fog horn. This is an instrument that it is necessary to have heard at night in the bloody and fantastic rays of the red light in order to appreciate its indefinable effect. Do not believe that it is unmusical. It is enormous, apocalyptic, but not discordant. It begins at first with the firing of a battalion, and this continues with thunder claps in *re*, *sol*, *ut* . . . at will. The artist who "plays" this horn has doubtless taken lessons from Azrael, the soloist of the last judgment. He adroitly passes from the sharpest to the gravest notes as if he were "pumping" the trombone. There is here a *tonitruante* harmony that both terrifies and charms the auditor. It is astonishing that we modern Wagnerians have not yet introduced the compressed air horn upon the stage or into the orchestra. It would be very suitable in one of those works drawn from chivalry, in which the monsters that guard the Yolandes and the Brunehildes so often play a somewhat simple and passive role.

A 70 kilogramme bell, designed to take the place of the horn in case the machine should be unable to operate, completes the sonorous system. The service of the lightships is assured by a large *personnel* selected from among the sailors of naval and merchant vessels. Every vessel receives a crew of eight men commanded by a practical merchant captain familiar with the surroundings and thoroughly acquainted with the maneuver of the light apparatus.

The change of crew on the vessels takes place every fortnight if the weather permits, and in winter, it often happens that the weather does not grant such permission. Then it is necessary to await a favorable change, and, when Madam Amphitrite has got over her nervous crisis, one goes home to embrace his wife and children.

This change of crew is quite an affair. In the first place it is necessary to go to a distance with a special steamer towing a long boat. Then it is necessary to tranship provisions, fresh water, spare stores and heavy packages of petroleum, tar, paint, etc. If it were merely a question of having the crew jump from the steamer on to the lightship or *vice versa*, the operation would be easier, but it is a true disembarkment that it is necessary to make in open sea. Now, every one knows that work of this kind is impossible, even in a port, when the water "gets its back up."

In order that the change of crew may be effected normally, it is well to come up alongside of the light vessel, and then everything proceeds quickly and well. Transshipment by the long boat, if the weather is cool, may also be accomplished, but it requires great precaution in the coming alongside, and should be employed only with extreme prudence. It is the best method of "breaking pipes" and "drowning Christians."

The heavy lightship, which rolls and pitches, does does not pardon the awkward. The life of the sailors on floating beacons is generally monotonous. Their principal occupation is to keep their "country house" in an extremely clean state; to paint, to soap, to furbish—to furbish, to paint and to soap! Aside from this, the sailors make tapestry, mats, models, or charming little ships all rigged with sails to the wind, which they introduce into a bottle.

From time to time, a heavy gale diverts the attention of the crew. Then the vessel budges, labors and navigates . . . almost! Sometimes the wind redoubles its force and tears the vessel from its reef. Such an accident, in which there is nothing amusing, does not displease the sailors. It gives them a change! All this confusion of the tempest rejuvenates these old salts. Several floating beacons have made some rare but very exciting promenades under sail amid the furies of the ocean, avoiding land, and giving the cape a wide berth. Well ballasted, very stable, and commanded and maneuvered by accomplished men, they have always drawn themselves, to their honor, out of such troubles.

Each sailor receives a yearly salary of 1,000 francs from eight months' board. On land, the crews are employed in the service of buoys and repairs. It is useless to add that three quarters of these brave fellows are decorated with life-saving medals. Their motto is: Patience, exactitude and devotion.

In principle, it has been decided that the lightships designed for the great banks shall be preserved. The Dyck and Ruytingen have therefore been reconstructed and provided with an illuminating apparatus more powerful than the preceding—1,200 carcel burners, instead of 40! The exigencies of the budget did not permit of reconstructing the other lightships. This would constitute an expense of 2,500,000 francs—absolutely out of proportion to the credits disposable. Moreover, the chambers do not appear to us favorable to new increases of the budget of lighthouses and beacons, and the expenses of the electric beacons and sonorous signals recognized as urgent, burden the general maintenance very heavily. In a few years, there will be such a disproportion between the needs to be satisfied and the resources of the beacon and buoy service that it will become necessary to take radical measures. Why might not the English system then be adopted? This requires that the interested, that is to say, navigators, shall be taxed upon their arrival in port according to the lights that they have had to take the bearings of before making land. It is very just, and, upon the whole, this rational tax falls upon the foreigners who profit by our maritime lighting, as well as upon our own ships.

At all events the first reform indicated is to suppress the apparatus that are expensive for the services that they render and to replace them by new ones that are much less costly and that produce the same effect of protection. This is the result that it is proposed to reach by substituting a series of luminous buoys for the lightships of second utility. The expenses of material, crew and maintenance will at once redescend to the normal.

The use of floating bodies anchored upon dangerous bottoms in order to signal the latter at the surface dates from remote times. It is to be supposed that in the creeks and mouths of rivers that served them as a refuge the navigators of antiquity had recourse to this method of avoiding the loss of their primitive vessels. Branches of trees, corks, fagots, casks, etc., were employed in succession.

The sailors of the middle ages improved buoying. Finally, Louis XIV. specified the duties of the port officers particularly as regards the buoys and beacons to be placed in the channels and in dangerous places. Unfortunately, the materials that were then at one's disposal were inadequate. They resisted the violence of the sea and of its currents but feebly and but for a short time. The cordage used to retain the floats at their post wore out, quickly rotted and broke, and the protective apparatus were no longer in place at the moment when navigation had the greatest use for them. Metallurgy in our age of iron has very advantageously modified the use of chains for anchoring, and of steel plate for the manufacture of buoys, and this has carried these floats to the highest degree of perfection. Not only are strong buoys of all sizes and forms now made, but also, thanks to their perfect tightness, it is easy to charge them with illuminating gas. True reservoirs, they are provided with pipes and a more or less powerful lantern. To the simple buoys there is generally given a biconical form. When it is desired to provide them with a light apparatus, their bulge is rounded in lowering their main section to about three-fourths of their total height. Then, according to the axis, rods of varying lengths are added to sustain the lantern, while a fusiform tail, properly ballasted, gives the buoy the necessary stability and power of righting itself.

The light of all the luminous buoys is produced by the rich gas of mineral oil, which is forced into the metallic body of the buoy at a pressure of seven atmospheres. The consumption is regulated at will like that of an ordinary burner. The lantern, provided with white or colored glasses, protects the burner from spray and gusts of wind. The focal plane, in buoys of the fourth class, can be carried to seven meters above the horizon and its power is capable of reaching 40 carcels, exactly what was given by the first lightships, at seven miles at least. The buoys of the sixth class do not emerge above five meters, which would still be sufficient did not the oscillations of the surges and the hollows of the waves interfere with their useful effect.

The buoys therefore are capable of indicating the route to follow and the dangers to avoid by day and by night. On coming from the open sea all those that are red must be left to the starboard and all those that are black must be left to the larboard. The turret buoys—fixed beacons painted red and black in horizontal stripes—can be left on either side, but at a good distance, however. Some buoys have a bell that the billows cause to sing; others are provided with horns actuated by a diaphragm that each wave sets in motion.

The six lights to be replaced cost 200,000 francs annually for maintenance and *personnel*. It suffices to say that 2,000 francs will satisfy the complete operation of a luminous buoy, in order to make understood the importance of the saving realized. Certainly, there is no intention of replacing a lightship by a buoy, but a minimum series of three illuminating buoys, forming a perfect triangulation, will give indications upon the reefs and banks just as precise as a single light of 40 burners. This has been victoriously demonstrated by experience.

The first trials of luminous buoys were made about 1887, in quarters where the experiment ought to have been conclusive—at the bank of Mauvaise at the mouth of the Gironde and at the plateau of Rochebonne. The success was complete—decisive. The anchor hold, despite the formidable efforts of the tempest, was perfect. The lights were not extinguished under the repeated shock of the waves and the blowing of the hurricane. Their visibility has always been normal, as has been ascertained every time that a methodical examination has been made. Thus, the Mauvaise light has been submitted for several years to three observations by night. More than five thousand observations have been correctly registered by the watchmen of the Grand Bank. They demonstrate the excellence of these apparatus.

A single objection can be made, with justice, to the use of luminous buoys: those whose light is white and stationary may be confounded, especially during calms, with the signal light of a ship at anchor. This objection, which is a very grave one, will remain in all its vigor as long as buoys with a white light are not uniformly provided with an apparatus for producing a flash or intermittent light.

In 1888, nine luminous buoys were put in service on the bank of the Kerkennah, in Tunis. They signaled dangers for a length of more than eight miles. It was a benefit, and yet routine raised its malevolent voice against these protective buoys. Success gradually asserted itself, and good sense silenced the most rabid adversaries. To-day the navigators of the Tunisian Mediterranean adore what they would have desired to sink.

The investigations that have just been made, especially at the Minquiers, have shown that fidelity to the things and customs of the past is more than ever rooted in the minds of our maritime population.

The coasters and fishermen of Saint Malo, Cancale and Granville, who alone are really interested in this question of the Minquiers, were consulted by the special commission. Naturally, like a single sailor, they demanded the maintenance of the old, worn out, and even unlighted, floating beacon. In order to explain this amusing request, let us say that the Minquiers lightship, anchored at about twelve miles from the nearest coffee house, has served since its installation as an inn and anchorage post to almost all the sailors of the region. When the quart is long to draw and the fish do not grumble, they go to say good-night to the lightvessel and whistle a *mi-camo* thereon. For such a purpose it is in fact not very important whether the lamp be lighted or not, even were it of 1,200 carcels power.

Upon the whole, the technical question is nearly solved. The luminous buoys, with their improvements foreseen, will to-morrow satisfy the service for which they are designed. A few extinctions have occurred, but these were due especially to the inexperience of those who had charge of their maintenance. The replacing of the Minquiers lightship by four luminous buoys of the fifth class, with a range of seven miles, situated at the approach to dangerous points instead of in the center of them, constitutes an undeniable progress. It remarkably enlarges the zone of protection, especially in the west, in passing through the north.

Navigators coming from the open sea, in order to make the port of Saint Malo, now know the precise route that they must take to leave in the east all the dangers of the Minquiers. They have there under their eyes a perfect alignment, while the old lightship could indicate only an approximate distance. Hesitation becomes impossible; one is or one is not out of line.

The special commission has therefore resolved, despite the more or less grotesque recriminations that have been presented to it, to maintain these three luminous buoys. It wishes even to add a fourth one at about 200 meters from the one that signals the breakers of the southwest. This coupling will give in a very lucid manner the exact bearing of the most advanced jutting of the flats.

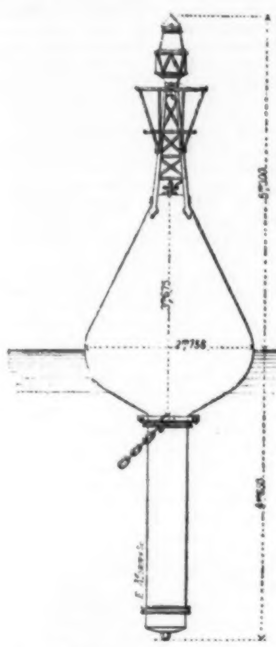
The luminous buoys of the Minquiers are, as we have said, of the fifth class. Their capacity is eleven cubic meters of gas, with a focal plane situated at five meters above the horizon. It were to be wished that these lights, a little low, especially during the surgings of the sea, could be replaced by apparatus similar to those of Rochebonne, the lantern of which illuminates at seven meters above the sea.

With the old Minquiers lightship, the zone of protection was about ten miles in clear weather. With luminous buoys this zone is nearly doubled in practice, especially in foggy weather, since it is possible to come upon buoys within the length of a boathook without danger.

However, the special commission does not as yet feel content with the result. It recommends to experts

the study of a true lightship carrying the focal plane at ten meters at least above the sea, and, during the day, possessing the visibility of the boats at present in place. This new boat would be provided with gas accumulators, would be firmly anchored, and be left to itself.

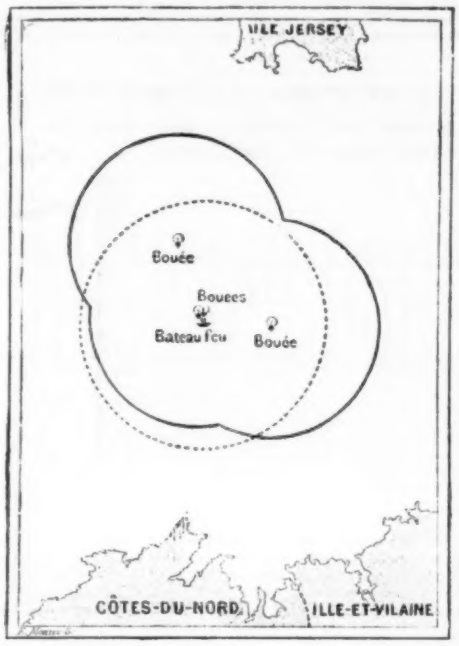
An unfortunate experiment with a lightship without a crew having been tried near Liverpool, many doubts are expressed as to the good performance of such a craft. On another hand, a floating beacon without crew, but with two guardians, having been anchored at Grepen, in the Gulf of Bothnia, has behaved very well without the light going out and without dragging anchor a single instant. These two contradictory experiments, while making one fear great difficulties, give a glimpse, however, of final success.



LUMINOUS BUOY OF THE FIFTH CLASS.

As for the buoys, their fixedness has never left anything to be desired, and yet they have been anchored in very difficult conditions. At Rochebonne a buoy of sixteen cubic meters and seven meters in height above the water has been maintained without any accident in depths of about fifty-five meters, at twelve hundred meters from the deep water where the swells coming from the open sea break with violence.

At the Minquiers the result is still more satisfactory. The three luminous buoys encountered the storm of November 11, 1891, without damage, a storm which was powerful enough to break the chains of the lightship and set it adrift. Since then they have withstood very furious assaults without exhibiting the least sign of damage. The demonstration is therefore as complete as possible.



SUBSTITUTION OF LUMINOUS BUOYS FOR LIGHTSHIPS AT THE MINQUIERS.

And to say that it is to good Philadelphus that we owe all this! For, in fact, we cannot refuse him the merit of the invention. The Arabian writers have even recorded that, before the monument of Alexandria, Ptolemy caused two floating beacons to be installed upon rafts at the entrance of the port. And, what is more, these were intermittent lights, for slaves whose eyes had been put out were made to walk around the brazier. There is therefore nothing new, not even the revolving lights that are lost in the clouds. Was not the Pharos of Sostrates a thousand cubits in height, or about one hundred and fifty meters higher than the Eiffel tower?

Meanwhile let us multiply the luminous buoys, and consequently diminish shipwrecks. More light, fewer orphans!—*L'Illustration.*

THE RUYTINGEN AT ANCHOR.

STORAGE BATTERIES IN FRENCH CENTRAL STATIONS.

We have from time to time given details of the employment of storage batteries in central stations abroad, more especially in England and in Germany, where these adjuncts to the central station equipment have met with extensive application, though progress in the same line in this country appears to be very slow. The French electrical engineers, however, have also recognized the value of these auxiliaries, with the result that numerous stations in France are now equipped with them.

The principal types of batteries in use in France are those of the Societe pour le Travail Electrique des Metaux and the Tudor storage batteries; in addition to these there may be mentioned the batteries made by Dujardin, Verdier, Gadot, Rousseau and the Societe Francaise des Accumulateurs.

The storage batteries of the Societe pour le Travail Electrique des Metaux consist of a series of plates built up of pastilles placed side by side and separated by a support of lead which is poured around them. The latter are then divided into smaller pastilles of about 2 centimeters square. The pastilles are separately prepared by means of a mixture of chloride of lead and chloride of zinc. This mixture is soaked in a dilute solution of hydrochloric acid which dissolves out the chloride of zinc. The pastilles are then dried and subjected to a hydrogen bath, which reduces them to spongy lead. The positives are obtained by peroxidizing the negatives. The plates thus formed are suspended in the cells on their upper ends in order that the plate may expand in all directions, and so that the active matter which falls is deposited at the bottom without forming short circuits.

The Tudor accumulators are already well known and have been fully described in these columns. For more than a year they have been regularly manufactured in France. The electrodes consist of lead plates which are heavily indented. These are first submitted to a Plante process for about two months and the indentations filled up with minium and litharge. The plate is then slightly compressed and subjected to a second formation; after several months an excellent accumulator is thus obtained. The insulation and the separation of the plates is obtained by means of glass tubes.

The plates of the Dujardin battery are built up of lead strips 6 millimeters wide and 1 millimeter thick, piled one on top of the other to form a plate. Upon this plate there is deposited electrolytically the product of the decomposition of an alkaline nitrate of lead. At the end of the process the positive electrode is covered with pure peroxide of lead. We will forego the descriptions of the other storage batteries, as they are tolerably well known, merely mentioning that of Tommasi of the multitubular type (familiar to our readers) which is now being tried experimentally for lighting railway cars in Paris.

The Tudor batteries for stationary work have a capacity of 5·34 ampere hours per kilogramme of plate when delivering at the rate of one ampere per kilogramme, the discharge being stopped at 1·85 volts. A discharge of two amperes per kilogramme of plate can, however, be obtained; their capacity ranges from 20,000 to 30,000 ampere hours. The manufacturers guarantee an ampere efficiency of 90 per cent. and a watt efficiency of 75 per cent. In actual practice, these figures are, it is said, often exceeded, and it is by no means rare that the ampere efficiency is 92 and the watt efficiency 80 to 82 per cent.; the discharge is stopped when the potential falls below 1·85. The Tudor Company has constructed a special type for electric traction, the maximum output of which, during normal running, is three amperes per kilogramme of plate.

The batteries of the Societe des Metaux have a capacity of 18·5 ampere hours per kilogramme of plate when discharging at the rate of one ampere per kilogramme. The type employed on the Northern Street Railway of Paris gives an ampere efficiency of 85 per cent. and a watt efficiency of 73 per cent. The Dujardin batteries have a useful capacity of 18 ampere hours per kilogramme of plate when discharged down to 1·8 volt.

The batteries of the Societe des Metaux are employed in Paris in the sector or district of the Popp Company. Twenty-five sub-stations are distributed in this sector. Each of these stations contains one, two or three batteries having a capacity each of 2,000 to 3,000 ampere hours. All these sub-stations are charged in series by the central station situated in the Boulevard Richard Lenoir, and which are equipped with Desroziers dynamos. Each of these sub-stations distributes the current to the districts in its immediate vicinity.

The central stations in Paris employ storage batteries to help out their regular service. The Edison station has a Tudor battery of 175 kilowatts capacity, established in a sub-station at the extreme end of its sector in the Rue de Chateaudun. The central stations of the Societe d'Eclairage et de Force par l'Electricite, four in number, have each three sets of batteries of the Societe des Metaux, of 2,000 ampere hours each. The central station of the Sector Clichy also has a Tudor battery of 456 kilowatts.

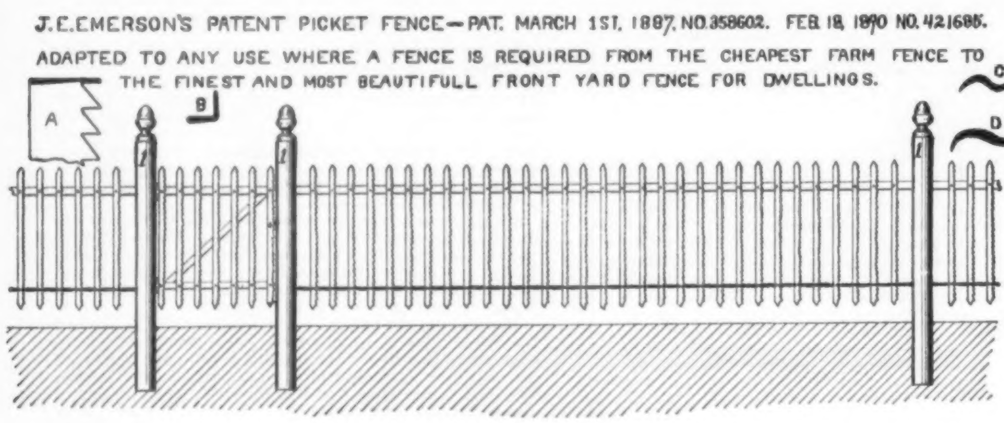
In general, the majority of the central stations established in France have one or more sets of storage batteries. Thus, we may mention among the central stations having Tudor storage batteries those at Angouleme, 15·6 kilowatts; Bordeaux, 19 kilowatts; Carcassonne, 60 kilowatts; Lyons (Gas Company) 90 kilowatts; Lyons (Tolozan) 18 kilowatts; Lyons (Bissuel) 12·25 kilowatts; Lyons (Bellecour) 16·75 kilowatts; Narbonne, 42 kilowatts; Rouen, 89·6 kilowatts; and St. Etienne, 79 kilowatts.

We have here mentioned only the principal installations; as a matter of fact it would appear that at the

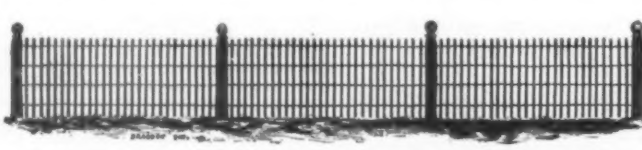
present time the utility of storage batteries in central stations is so well recognized in France that no new station is there established without providing for one.—*Electrical Engineer.*

EMERSON'S IMPROVED PICKET FENCE.

It is well known that barbed wire fence is both dangerous to young stock and cruel to all kinds of cattle and horses, so that several States have prohibited its use by law. For farmers' use a cheap and, if need be,

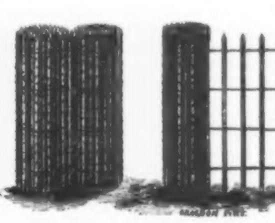


movable fence is wanted—one so constructed that vicious animals will not jump it or tear it down, nor rub against it and push it over. For protecting lawns, flower gardens, or orchards, the fence shown in the illustration is a most perfect construction, as it is



WITHOUT BASE BOARD OR TOP RAIL, FOR A CHEAP RURAL FENCE.

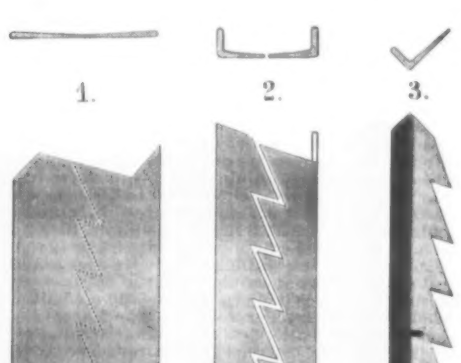
almost impossible for mischievous boys to climb over it, and the sharp forks at the lower ends of the pickets prevent swine from crawling under, while the serrated edge prevents all animals from rubbing against it or vicious animals tearing it down. The posts are



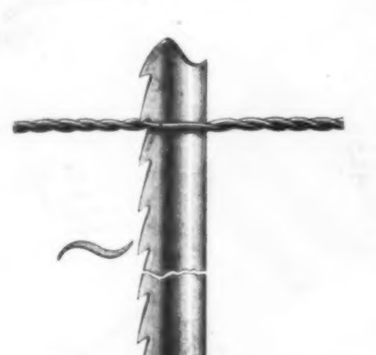
FENCE IN ROLLS READY FOR CRATING FOR SHIPMENT.

either wood or iron, and of varied patterns, when used upon grounds around a private dwelling.

In the larger illustrations showing the construction, Fig. 1 represents the metal blank at it leaves the rolling mill, Fig. 2 indicating the next step, with the



FORMING FENCE PICKETS FROM THE BLANKS.



INSERTING PICKETS IN WIRE FENCE.

edges turned up, and Fig. 3 showing it toothed and in a V shape, giving great strength with very little metal. Rolling mills and wire manufacturers or others desiring further information relative to this fence, or its manufacture, should address the Universal Safety Fence Co., Beaver Falls, Pa., P. O. box 75.

THE SULPHUR INDUSTRY OF SICILY.

An exhaustive report of the British vice-consul at Palermo on the production of and trade in Sicilian sulphur has lately been issued by the Foreign Office. Sulphur has, it appears, been extracted in Sicily to some extent for centuries, but it is only within the last sixty or seventy years that the industry has come into general and active operation. The quantity of ore extracted in 1891 was, according to the *Times*, more than 2,500,000 tons; and the mineral obtained from this was 347,568 tons, of which 310,272 tons were exported. When compared with the production and exportation of 1830, which was 38,461 tons, it will be seen that the development attained was very great, but it must be remembered that Sicily is really the only sulphur-producing country in the world, the few thousand tons exported by Japan not affecting Sicily in any way. The number of mines in 1891 was 818, of which 581 were working and 237 closed. The men finding work in and about the mines were 32,269, not including carters, drivers, carriers, storekeepers, etc., who are all directly or indirectly engaged in the trade. The total is roughly given at 50,000. The persons working in the mines in Sicily are generally termed "esercenti," and are divided into three classes—viz., owners, leaseholders, and contractors. Some proprietors work their mines themselves, while others lease them on what are called "gabella," and sometimes the proprietors and the leaseholders have their mines worked by "partitanti," or contractors. The "gabella" of a sulphur mine has all the forms of a special contract, whereby the proprietor grants to the leaseholder, at the entire cost and charge of the latter, the working of a mine for a given number of years under determined conditions, the main one being that the owner shall have, free of all expense and at his choice, a certain proportion, 20 per cent. on an average, known as the "gabella" or rent, of the mineral produced. The "partito" is a verbal agreement without a definite limit of time, lasting until one of the parties recedes from it or proposes a change. By this verbal agreement the working of a mine or part of a mine, the fusion of the ore, the cost of labor, maintenance, etc., are undertaken by a foreman workman for a fixed compensation in money for every 264 lb. yielded. As a general rule the methods for working the mines are still very primitive, for when the proprietors work the mines themselves they generally contract with a "partitante" and endeavor to get the greatest output at the least cost; the "partitante" is thus precluded from investing money in plant and machinery, and if the owners are of the patrician class and live away from their estates, these contracts are managed by their local agents. The system of the "gabella" is preferred all round, for the "gabelloto" is enterprising and thoroughly acquainted with the mine and its resources, with the miners and their habits and exactions, and he possesses all the qualifications for managing a mine, except capital; hence he has recourse to a money lender, or to a speculator, who lends the money at exorbitant interest. The greater part of the ore at the various mines is still fused by the old method of "calcaroni," or open kilns, owing to the cost of their construction being much less than the adoption of other methods, but the loss of sulphur caused by the escaping fumes is very great. Improved systems are in use in most of the mines with which English companies are connected. Refining is carried on at Catania. There are seven refineries. The largest is capable of turning out 48 tons of refined sulphur in 24 hours, 2,000 tons of flour of sulphur during a season, and of milling 3,000 half hundredweight bags of sulphur per day. The refining season commences in October and terminates in June. There seems to be a steady decline in the exports to the United Kingdom, due to the manufacture of sulphuric acid by means of Messrs. Chance's process, but it is thought in Sicily that there is no ground for fearing that any reductions in exports will be caused thereby—Chance's process being still looked upon as of doubtful financial profit, though its success scientifically is undoubted. Another diminution is observable in the exports to the United States, where pyrites have also taken the place of sulphur in chemical and other works. The vice-consul concludes by describing the working of one of the most important and best managed of the mines, viz., Grottacalda, situated at about 7 kiloms. from the town of Valguarnera, and 21 kiloms. from the nearest railroad station of Assaro. It belongs to Prince Sant' Elia, and is at present leased to and worked by Messrs. J. Trewhella & Co. It produces about 15,000 tons of sulphur yearly, of which 22 per cent. is made over to the proprietor as rent. The extreme depth is 140 meters. There are three shafts, besides various "scala" or stairs leading into the mine. At the main shaft the ore is drawn to the surface by a 60 horse power horizontal winding engine, the cage containing a tram wagon with about 15 cwt. of ore at a time. The ore is extracted from the two smaller shafts by modern steam winches of 8 to 10 horse power. There are three horizontal Lancashire boilers, each having 30 square meters of superficial heating surface, and two vertical boilers for driving the steam winches. The amount of water is about 1,000 cubic meters in 24 hours, and is extracted by a double-acting vertical beam pump (Cornish pattern) working in three lifts; the length of stroke is three meters, diameter of plunger 30 centims., speed of pump six strokes per minute; besides this there are three Worthington pumps in reserve in case of accidents. The quantity of ore brought to the surface in 24 hours is about 300 tons. The ore yields about 3½ cwt. of fused sulphur per ton. There are about 150 miners and 250 boys employed underground, divided into three shifts, besides an underground engineer and several foremen. The sulphur, when fused, is taken to the railroad station by carts, 50 of which are regularly employed, and at times these are increased to 100; each cart takes about 14 cwt. of sulphur.

THE SALT INDUSTRY OF ASTRAKHAN.

The following is a special report issued by the Foreign Office on the salt industry of Astrakhan, the report having been made by the British consul at Taganrog.

The Trans-Volga steppes, in the province of Astrakhan, form an extensive salt basin, composed of the largest known salt lakes, Elton and Baskunchak, a whole group of the so-called South Astrakhan salt lakes, and large beds of rock salt in the Chapchachi Hill. At present the salt is extracted only from the Baskunchak and South Astrakhan lakes. One great element in the development of the industry was the establishment of steam communication on the Volga and the consequent diminution of the cost of transport. During 116 years (1747–1862) the lake was worked by the government, but from 1866 to 1882 it was in the hands of private individuals. The Elton lake is one of the largest and richest salt lakes known to exist, and covers an area of 135 square miles. The thickness of the salt bed is unknown. As far back as 1885 attempts were made to dig a well, but the work had to be abandoned at the depth of 14 ft., owing to the hardness of the salt and foul air, which prevented the laborers from stopping down more than ten minutes at a time. The salt was worked by primitive means, the only tools used being crowbars, pickaxes, and spades, and it was transported to the shore on specially constructed rafts carrying from 1 to 1½ tons. The principal drawback to the development of the industry was the great expense of transporting the salt to the landing stages at Grialkin and Nicolaevsk on the Volga. Operations on the Baskunchak lake were first begun in the middle of the last century, but the output was very limited, and, owing to the serious competition of Elton salt, it dropped off altogether. It was only in 1867 that a fresh start was made. Statistics show that since then the output has increased very rapidly and without any serious fluctuations, which proves that the production has not been fostered by artificial measures, but has simply followed the increased demand for salt. The Baskunchak lake has an area of 66 square miles. Surveys made in 1883 prove the bed to be from 20 ft. to 28 ft. deep. The mode of extraction is similar to that practiced at Elton lake. Blasting with dynamite was introduced in 1877, but it is very rarely resorted to. The cost of production up to the time of the closing of the Elton establishments was the same as at the last named, the sole difference being in the cost of transport to the landing stages on the Volga. Thus from Elton it was 2¼d. per pood, whereas from Baskunchak it was only 1¼d. per pood of 36 lb. The salt industry of the South Astrakhan lakes is chiefly carried on in the southwest of Astrakhan, in the neighborhood of the Nicolaievka, Liteinaya, and Bassova villages. Here there are altogether over seventy lakes, more than half of which are being worked. These are, as compared with Elton and Baskunchak, insignificant, and it has been remarked that if the production be pushed too much, the salt

immediately deteriorates both in quality and quantity. This is explained by the fact that in working the evaporated salt all the bitter magnesia salts are washed out by the brine and thus returned to the lake. The Chapchachi Hill is a solid mass of rock salt; it is about 53 miles to the south of the Baskunchak lake and 57 miles east of the Volga. The hill is only about 90 ft. high; its length is about two miles, and breadth 4,900 ft. According to surveys, the salt strata are about 280 ft. thick, but the total quantity of salt has not yet been determined.

PRESIDENT CARNOT.

"MR. CARNOT is dying!" "Mr. Carnot is dead!" Such was the cry of alarm that recently reverberated through Paris, and that, transmitted by telegraphic agencies, soon made the tour of Europe. It will soon be a month ago that the alleged death of Mr. Carnot was skillfully prepared by the Lemice-Terrieux of the Parisian information.

The *Illustration* is fond of clearing up mysteries, so it sent two of the members of its staff to Fontainebleau with the mission of making as thorough an inquiry as possible and of informing its readers by convincing facts and palpable proofs.

On our arrival at the palace, we found General Borins deeply immersed in the reading of the morning papers and greatly amusing himself over the various comments of the "well informed" journals. The door of the neighboring *salon* soon opened wide, and the president, ready to take his morning walk in the English garden, came to ask the military majordomo to please accompany him.

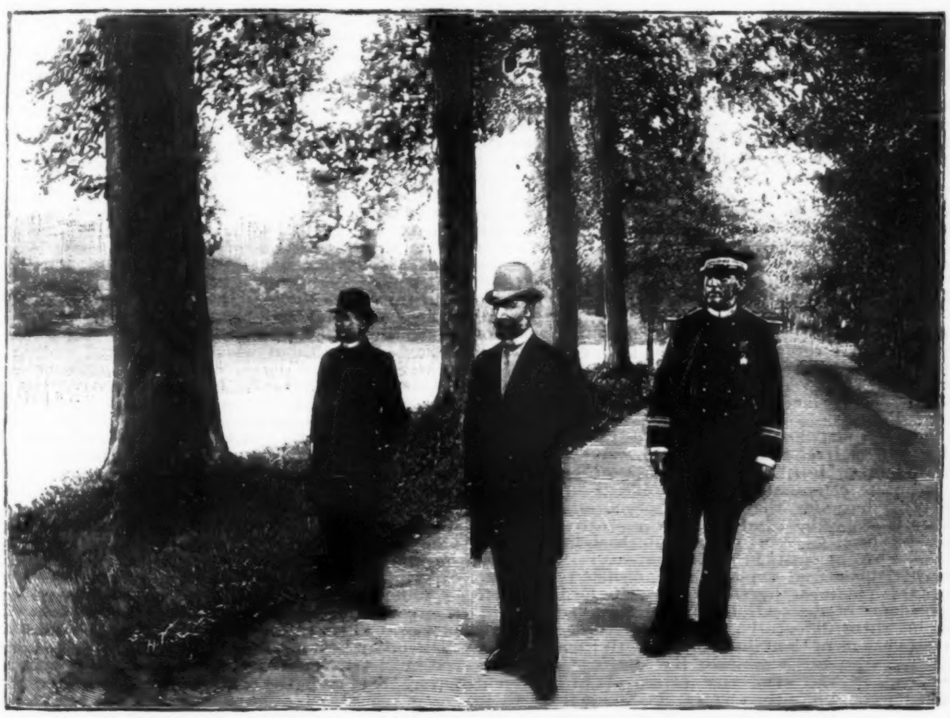
"So you, too, have come to get news of me," said he, laughing heartily. "Well! you see that I still continue to live!" And, taking leave of us, Mr. Carnot, accompanied by General Borins and Commandant Marin-Darbel, the new officer of the military household, descended the front steps of the officers' *salon* and directed himself toward the lake.

Remembering, then, the object of our visit, we walked out very quietly through the gate to the right, and, at the end of a few instants' observation, caught sight of the three promenaders as they passed by.

Mr. Carnot will please pardon us for this indiscreet "snap-shot." We have thought that it was likely the best means of showing that the head of the government was, on the 6th day of September, at 11 o'clock in the morning, that is to say, on the very day after his "death," in a most flourishing state of health.

For the foregoing and for our engraving we are indebted to *L'Illustration*. The central figure represents the president.

Marie Francois Sadi Carnot, now president of the French republic, was born at Limoges, August 11, 1837. He comes of a family which for the last hundred years has played an important part in the political history of France. His grandfather was Lazar Nicolas Carnot, who was minister of war under Napoleon I. His father was Lazar Hippolyte Carnot, minister of education under the second empire. He is also the grand-nephew of N. L. Sadi Carnot, who rendered such distinguished services to the cause of science by his investigations on the motive power of heat. Coming from such ancestry much might have been expected from M. Carnot, and his career has amply fulfilled these expectations. He was educated at *Ecole Polytechnique* and the *Ecole des Ponts et Chaussees*. M. Carnot carried on many important engineering works, and did not enter public life until January 10, 1871, when he was appointed prefect of the department of Seine Inferieure, and on February 8 he was elected as representative of the department of the Cote d'Or in the National Assembly. He gave great attention to the public works of France, for which he was peculiarly qualified by reason of his profession of civil engineer. He was appointed under-secretary of public works in 1877 and became minister of public works in 1880-82, which office he held until he became minister of finance in 1882. In 1886 he again became minister of finance, and on December 3, 1887, he was elected president of the French republic, *vice* M. Francois Paul Jules Grevy, resigned. President Carnot has conducted the ship of state through many serious perils, and by his unswerving integrity has won the confidence of the French people.



PRESIDENT CARNOT AT FONTAINEBLEAU.

A DISTINGUISHED AMERICAN BONAPARTE.

JEROME NAPOLEON BONAPARTE, the grand-nephew of the great Corsican, and the most famous representative in these later days of the American branch of the Bonaparte family, died in Beverly, Mass., his summer home, September 3. He was born in Baltimore in 1832, his father being Jerome Napoleon Bonaparte, son of Jerome, youngest brother of the Emperor, and Elizabeth Patterson, of Baltimore, and his mother being Miss Williams, of Roxbury. The third Jerome entered Harvard College, but left to accept a cadetship at the West Point Military Academy, from which he was graduated in 1852. He served in the United States mounted infantry on the Texan frontier, but resigned his commission to enter, September 5, 1854, the French army as second lieutenant of the Seventh Dragoons. He served throughout the Crimean war as an engineer, and distinguished himself at Balaklava, Inkerman and Sebastopol, being afterward decorated by the Sultan of Turkey, Queen Victoria and the French Emperor. Among his various rewards was the decoration of a knight of the Legion of Honor. Colonel Bonaparte also served in the Algerian campaign of 1856-57, and in the Italian campaign against Austria in 1859, being engaged at Montebello and Solferino. From 1865 to 1867 he was on garrison duty at various posts, and from 1867 to 1871 he was in the guard of the Empress Eugenie. At the fall of the second empire Colonel Bonaparte narrowly escaped with his life from Paris, which was then in the hands of the Commune. He at once returned to this country and settled down to a life of peaceful domesticity, marrying in 1871 Mrs. Caroline Le Roy Edgar, daughter of Samuel Appleton, of Boston, and a relative of Daniel Webster. In 1873 Colonel Bonaparte returned to France, where he remained until 1879, when he returned finally to the United States just prior to the death of his grandmother, Elizabeth Patterson Bonaparte, of Baltimore. Since then he has lived principally in Washington and Newport, R. I. He leaves two children, Jerome Charles, born in 1878, and Louise Eugenie, born in 1873, besides his wife. The well known Baltimore lawyer, Charles Joseph Bonaparte, is his younger brother.

The story of the origin of the American branch of the Bonaparte family is one of the romances of history. The youngest brother of the First Consul was an officer in the French navy when he met Elizabeth Patterson at a ball in Baltimore in 1803. She was then about seventeen years old, and the daughter of a Baltimore merchant who was born in Ulster, Ireland. It was a genuine love match, and the marriage was duly consummated, notwithstanding the opposition of the paternal Patterson, who foresaw how Napoleon would view it. The young wife was prevented by French frigates from landing in France, and her son was born in England in 1805. Jerome Bonaparte's American marriage was nullified by the Emperor, but the Pope and Roman Catholic Church always recognized it, and it was afterward decreed by an imperial council of the second empire that Elizabeth Patterson and her son had the right to the name of Bonaparte. After the annulment of his American marriage by the Emperor, Jerome married Catherine, Princess of Wurtemburg, became King of Westphalia, and served in the Emperor's army, commanding a division at Waterloo. Elizabeth Patterson died in Baltimore in 1879, and her husband near Paris in 1860. The elder Jerome Bonaparte certainly did not behave handsomely to his American wife, and it made her misanthropic in her later years.—*Springfield Republican.*

[Continued from SUPPLEMENT, No. 928, page 14833.]

BIOLOGY AND ITS RELATIONS WITH OTHER BRANCHES OF SCIENCE.

By J. S. BURDON-SANDERSON, M.A., M.D., LL.D., D.C.L., F.R.S., F.R.S.E., Professor of Physiology in the University of Oxford.*

THE SPECIFIC ENERGIES OF THE ORGANISM.

WHEN in 1826 J. Muller was engaged in investigating the physiology of vision and hearing, he introduced into the discussion a term "specific energy," the use of which by Helmholtz† in his physiological writings has rendered it familiar to all students. Both writers mean by the word energy, not the "capacity of doing work," but simply activity, using it in its old-fashioned meaning, that of the Greek word from which it is derived. With the qualification "specific," it serves, perhaps, better than any other expression to indicate the way in which adaptation manifests itself. In this more extended sense the "specific energy" of a part or organ—whether that part be a secreting cell, a motor cell of the brain or spinal cord, or one of the photogenous cells which produce the light of the glowworm, or the protoplasmic plate which generates the discharge of the torpedo—is simply the special action which it normally performs, its norma or rule of action being in each instance the interest of the organism as a whole of which it forms part, and the exciting cause some influence outside of the excited structure, technically called a stimulus. It thus stands for a characteristic of living structures which seems to be universal. The apparent exceptions are to be found in those bodily activities which, following Bichat, we call vegetative, because they go on, so to speak, as a matter of course; but the more closely we look into them the more does it appear that they form no exception to the general rule, that every link in the chain of living action, however uniform that action may be, is a response to an antecedent influence. Nor can it well be doubted that as every living cell or tissue is called upon to act in the interest of the whole, the organism must be capable of influencing every part so as to regulate its action. For, although there are some instances in which the channels of this influence are as yet unknown, the tendency of recent investigations has been to diminish the number of such instances. In general there is no difficulty in determining both the nature of the central influence exercised and the relation between it and the normal function. It may help to illustrate this relation to refer to the expressive word *Auslosung*, by which it has for many years been designated by German writers. This word stands for the performance of function by the "letting off" of "specific energies." Carrying out the notion of "letting off" as expressing the link between action and reaction, we might compare the whole process to the mode of working of a repeating clock (or other similar mechanism), in which case the pressure of the finger on the button would represent the external influence or stimulus, the striking of the clock the normal reaction. And now may I ask you to consider in detail one or two illustrations of physiological reaction—of the letting off of specific energy?

The repeater may serve as a good example, inasmuch as it is, in biological language, a highly differentiated structure, to which a single function is assigned. So also in the living organism, we find the best examples of specific energy where Muller found them, namely, in the most differentiated, or as we are apt to call them the highest structures. The retina, with the part of the brain which belongs to it, together constitute such a structure, and will afford us therefore the illustration we want, with this advantage for our present purpose, that the phenomena are such as we all have it in our power to observe in ourselves. In the visual apparatus the principle of normality of reaction is fully exemplified. In the physical sense the word "light" stands for ether vibrations, but in the sensuous or subjective sense for sensations. The swings are the stimulus, the sensations are the reaction. Between the two comes the link, the "letting off," which it is our business to understand.

Here let us remember that the man who first recognized this distinction between the physical and the physiological was not a biologist, but a physicist. It was Young who first made clear (though his doctrine fell on unappreciative ears) that, although in vision the external influences which give rise to the sensation of light are infinitely varied, the responses need not be more than three in number, each being, in Muller's language, a "specific energy" of some part of the visual apparatus. We speak of the organ of vision as *highly differentiated*, an expression which carries with it the suggestion of a distinction of rank between different vital processes. The suggestion is a true one; for it would be possible to arrange all those parts or organs of which the bodies of the *higher* animals consist in a series, placing at the lower end of the series those of which the functions are continuous, and therefore called vegetative; at the other, those highly specialized structures, as, *e. g.*, those in the brain, which in response to physical light produce physiological, that is subjective, light; or, to take another instance, the so-called motor cells of the surface of the brain, which in response to a stimulus of much greater complexity produce voluntary motion. And just as in civilized society an individual is valued according to his power of doing one thing well, so the high rank which is assigned to the structure, or rather to the "specific energy" which it represents, belongs to it by virtue of its specialization.

And if it be asked how this conformity is manifested, the answer is, by the quality, intensity, duration and extension of the response, in all which respects vision serves as so good an example that we can readily understand how it happened that it was in this field that the relation between response and stimulus was first clearly recognized. I need scarcely say that, however interesting it might be to follow out the lines of inquiry thus indicated, we cannot attempt it this evening. All that I can do is to mention one or two recent observations which, while they serve as illustrations, may perhaps be sufficiently novel to interest even those who are at home in the subject.

Probably every one is acquainted with some of the

* Presidential address, British Association, Nottingham, 1893.

† "Handb. der physiologischen Optik," 1886, p. 233. Helmholtz uses the word in the plural—the "energies of the nerves of special sense."

familiar proofs that an object is seen for a much longer period than it is actually exposed to view; that the visual reaction lasts much longer than its cause. More precise observations teach us that this response is regulated according to laws which it has in common with all the higher functions of an organism. If, for example, the cells in the brain of the torpedo are "let off"—that is, awakened by an external stimulus—the electrical discharge, which, as in the case of vision, follows after a certain interval, lasts a certain time, first rapidly increasing to a maximum of intensity, then more slowly diminishing. In like manner, as regards the visual apparatus, we have, in the response to a sudden invasion of the eye by light, a rise and fall of a similar character. In the case of the electrical organ, and in many analogous instances, it is easy to investigate the time relations of the successive phenomena, so as to represent them graphically. Again, it is found that in many physiological reactions the period of rising "energy" (as Helmholtz called it) is followed by a period during which the responding structure is not only inactive, but its capacity for energizing is so completely lost that the same exciting cause which a moment before "let off" the characteristic response is now without effect.

As regards vision, it has long been believed that these general characteristics of physiological reaction have their counterpart in the visual process, the most striking evidence being that in the contemplation of a lightning flash—or better, of an instantaneously illuminated white disk*—the eye seems to receive a double stroke, indicating that, although the stimulus is single and instantaneous, the response is reduplicated. The most precise of the methods we until lately possessed for investigating the wax and wane of the visual reaction were not only difficult to carry out, but left a large margin of uncertainty. It was therefore particularly satisfactory when M. Charpentier, of Nancy, whose merits as an investigator are perhaps less known than they deserve to be, devised an experiment of extreme simplicity which enables us not only to observe, but to measure with great facility both phases of the reaction. It is difficult to explain even the simplest apparatus without diagrams; you will, however, understand the experiment if you will imagine that you are contemplating a disk, like those ordinarily used for color mixing; that it is divided by two radial lines which diverge from each other at an angle of 60°; that the sector which these lines inclose is white, the rest black; that the disk revolves slowly, about once in two seconds. You then see, close to the front edge of the advancing sector, a black bar, followed by a second at the same distance from itself, but much fainter. Now the scientific value of the experiment consists in this, that the angular distance of the bar from the black border is in proportion to the frequency of the revolutions—the faster, the wider. If, for example, when the disk makes half a revolution in a second the distance is ten degrees, this obviously means that when light bursts into the eye the extinction happens one-eighteenth of a second after the excitation.†

The fact thus demonstrated that the visual reaction consequent on an instantaneous illumination exhibits the alternations I have described has enabled M. Charpentier to make out another fact in relation to the visual reaction which is, I think, of equal importance. In all the instances, excepting the retina, in which the physiological response to stimulus has a definite time limitation, and in so far resembles an explosion, in other words, in all the higher forms of specific energy, it can be shown experimentally that the process is propagated from the part first directly acted on to other contiguous parts of similar endowment. Thus in the simplest of all known phenomena of this kind, the electrical change, by which the leaf of the Dionæa plant responds to the slightest touch of its sensitive hairs, is propagated from one side of the leaf to the other, so that in the opposite lobe the response occurs after a delay which is proportional to the distance between the spot excited and the spot observed. That in the retina there is also such propagation has not only been surmised from analogy, but inferred from certain observed facts. M. Charpentier has now been able by a method which, although simple, I must not attempt to describe, not only to prove its existence, but to measure its rate of progress over the visual field.

There is another aspect of the visual response to the stimulus of light which, if I am not trespassing too long on your patience, may, I think, be interesting to consider. As the relations between the sensations of color and the physical properties of the light which excites them are among the most certain and invariable in the whole range of vital reactions, it is obvious that they afford as fruitful a field for physiological investigation as those in which white light is concerned. We have on one side physical facts, that is, wave lengths or vibration rates; on the other, facts in consciousness—namely, sensations of color—so simple that notwithstanding their subjective character there is no difficulty in measuring either their intensity or their duration. Between these there are *lines of influence*, neither physical nor psychological, which pass from the former to the latter through the visual apparatus (retina, nerve, brain). It is these lines of influence which interest the physiologist. The structure of the visual apparatus affords us no clews to trace them by. The most important fact we know about them is that they must be at least three in number.

It has been lately assumed by some that vision, like every other specific energy, having been developed progressively, objects were seen by the most elementary forms of eye only in chiaroscuro, that afterward some colors were distinguished, eventually all. As regards hearing it is so. The organ which, on structural grounds, we consider to represent that of hearing in animals low in the scale of organization—as, *e. g.*, in the Ctenophora—has nothing to do with sound,‡ but confers on its possessor the power of judging of the direction of its own movements in the water in which it swims, and of guiding these movements accordingly. In the lowest vertebrates, as, *e. g.*, in the

* The phenomenon is best seen when, in a dark room, the light of a luminous spark is thrown on a white screen with the aid of a suitable lens.

† Charpentier, "Reaction oscillatoire de la Retine sous l'influence des excitations lumineuses," *Archives de Physiol.*, vol. xxiv., p. 541, and *Propagation de l'action oscillatoire*, etc., p. 362.

‡ Verworn, "Gleichgewicht u. Otolithenorgan," *Pflüger's Archiv.* vol. l., p. 423; also Ewald's "Researches on the Labyrinth as a Sense Organ" ("Ueber das Endorgan des Nervus octavus," Wiesbaden, 1892).

dogfish, although the auditory apparatus is much more complicated in structure, and plainly corresponds with our own, we still find the particular part which is concerned in hearing scarcely traceable. All that is provided for is that sixth sense, which the higher animals also possess, and which enables them to judge of the direction of their own movements. But a stage higher in the vertebrate series we find the special mechanisms by which we ourselves appreciate sounds beginning to appear—not supplanting or taking the place of the imperfect organ, but added to it. As regards hearing, therefore, a new function is acquired without any transformation or fusion of the old into it. We ourselves possess the sixth sense, by which we keep our balance and which serves as the guide to our bodily movements. It resides in the part of the internal ear which is called the labyrinth. At the same time we enjoy along with it the possession of the cochlea, that more complicated apparatus by which we are able to hear sounds and to discriminate their vibration rates.

As regards vision, evidence of this kind is wanting. There is, so far as I know, no proof that visual organs which are so imperfect as to be incapable of distinguishing the forms of objects may not be affected differently by their colors. Even if it could be shown that the least perfect forms of eye possess only the power of discriminating between light and darkness, the question whether in our own such a faculty exists separately from that of distinguishing colors is one which can only be settled by experiment. As in all sensations of color the sensation of brightness is mixed, it is obvious that one of the first points to be determined is whether the latter represents a "specific energy" or merely a certain combination of specific energies which are excited by colors. The question is not whether there is such a thing as white light, but whether we possess a separate faculty by which we judge of light and shade—a question which, although we have derived our knowledge of it chiefly from physical experiment, is one of eye and brain, not of wave lengths or vibration rates, and is therefore essentially physiological.

There is a German proverb which says, "Bei Nacht sind alle Katzen grau." The fact which this proverb expresses presents itself experimentally when a spectrum projected on a white surface is watched, while the intensity of the light is gradually diminished. As the colors fade away they become indistinguishable as such, the last seen being the primary red and green. Finally they also disappear, but a gray band of light still remains, of which the most luminous part is that which before was green.* Without entering into details, let us consider what this tells us of the specific energy of the visual apparatus. Whether or not the faculty by which we see gray in the dark is one which we possess in common with animals of imperfectly developed vision, there seems little doubt that there are individuals of our own species who, in the fullest sense of the expression, have no eye for color; in whom all color sense is absent; persons who inhabit a world of gray, seeing all things as they might have done had they and their ancestors always lived nocturnal lives. In the theory of color vision, as it is commonly stated, no reference is made to such a faculty as we are now discussing.

Prof. Hering, whose observations as to the diminished spectrum I referred to just now, who was among the first to subject the vision of the *totally* color blind to accurate examination, is of opinion, on that and on other grounds, that the sensation of light and shade is a specific faculty. Very recently the same view has been advocated on a wide basis by a distinguished psychologist, Prof. Ebbinghaus.† Happily, as regards the actual experimental results relating to both these main subjects, there seems to be a complete coincidence of observation between observers who interpret them differently. Thus the recent elaborate investigations of Captain Abney‡ (with General Festing), representing graphically the results of his measurements of the subjective values of the different parts of the diminished spectrum, as well as those of the fully illuminated spectrum as seen by the totally color blind, are in the closest accord with the observations of Hering, and have, moreover, been substantially confirmed in both points by the measurements of Dr. Konig in Helmholtz' laboratory at Berlin.§

That observers of such eminence as the three persons whom I have mentioned, employing different methods and with a different purpose in view, and without reference to each other's work, should arrive in so complicated an inquiry at coincident results, augurs well for the speedy settlement of this long debated question. At present the inference seems to be that such a specific energy as Hering's theory of vision postulates actually exists, and that it has for associates the color-perceiving activities of the visual apparatus, provided that these are present; but that whenever the intensity of the illumination is below the chromatic threshold—that is, too feeble to awaken these activities—or when, as in the totally color blind, they are wanting, it manifests itself independently; all of which can be most easily understood on such a hypothesis as has lately been suggested in an ingenious paper by Mrs. Ladd Franklin,‖ that each of the elements of the visual apparatus is made up of a central structure for the sensation of light and darkness, with collateral appendages for the sensations of color—it being, of course, understood that this is a mere diagrammatic representation, which serves no purposes beyond that of facilitating the conception of the relation between the several "specific energies."

EXPERIMENTAL PSYCHOLOGY.

Resisting the temptation to pursue this subject further, I will now ask you to follow me into a region which, although closely connected with the subjects

* Hering, "Untersuch. eines total Farbenblinden," *Pflüger's Arch.*, vol. xlix., 1891, p. 563.

† Ebbinghaus, "Theorie des Farbensehens," *Zeitschr. f. Psychol.*, vol. v., 1893, p. 145.

‡ Abney and Festing, "Color Photometry," Part III. *Phil. Trans.*, vol. clxxxiii., A, 1891, p. 531.

§ Konig, "Ueber den Helligkeitwerth der Spectralfarben bei verschiedener absoluter Intensitat," *Beiträge zur Psychologie*, etc., "Festschrift zu H. von Helmholtz, 70, Geburtstage," 1891, p. 309.

‖ Christine Ladd Franklin, "Eine neue Theorie der Lichtempfindungen," *Zeitschr. fur Psychologie*, vol. iv., 1893, p. 211; see also the Proceedings of the last Psychological Congress in London, 1892.

we have been considering, is beset with greater difficulties—the subject in which, under the name of physiological or experimental psychology, physiologists and psychologists have of late years taken a common interest—a borderland not between fact and fancy, but between two methods of investigation of questions which are closely related, which here, though they do not overlap, at least interdigitate. It is manifest that, quite irrespectively of any foregone conclusion as to the dependence of mind on processes of which the biologist is accustomed to take cognizance, mind must be regarded as one of the "specific energies" of the organism, and should on that ground be included in the subject matter of physiology. As, however, our science, like other sciences, is limited not merely by its subject but also by its method, it actually takes in only so much of psychology as is experimental. Thus sensation, although it is psychological, and the investigation of its relation to the special structures by which the mind keeps itself informed of what goes on in the outside world, have always been considered to be in the physiological sphere. And it is by anatomical researches relating to the minute structure and to the development of the brain, by observation of the facts of disease, and above all by physiological experiment, that those changes in the ganglion cells of the brain and spinal cord which are the immediate antecedents of every kind of bodily action have been traced. Between the two—that is, between sensation and the beginning of action—there is an intervening region which the physiologist has hitherto willingly resigned to psychology, feeling his incompetence to use the only instrument by which it can be explored—that of introspection. This consideration enables us to understand the course which the new study (I will not claim for it the title of a new science, regarding it as merely a part of the great science of life) has hitherto followed, and why physiologists have been unwilling to enter on it. The study of the less complicated internal relations of the organism has afforded so many difficult problems that the most difficult of all have been deferred; so that although the psycho-physical method was initiated by E. H. Weber in the middle of the present century, by investigations* which formed part of the work done at that epoch of discovery, and although Prof. Wundt, also a physiologist, has taken a larger share in the more recent development of the new study, it is chiefly by psychologists that the researches which have given to it its importance as a new discipline have been conducted.

Although, therefore, experimental psychology has derived its methods from physical science, the result has been not so much that physiologists have become philosophers, as that philosophers have become experimental psychologists. In our own universities, in those of America, and still more in those of Germany, psychological students of mature age are to be found who are willing to place themselves in the dissecting room side by side with beginners in anatomy, in order to acquire that exact knowledge of the framework of the organism without which no man can understand its working.

Those, therefore, who are apprehensive lest the regions of mind should be invaded by the *insaniens sapientia* of the laboratory, may, I think, console themselves with the thought that the invaders are for the most part men who before they became laboratory workers had already given their allegiance to philosophy; their purpose being not to relinquish definitively, but merely to lay aside, for a time, the weapons in the use of which they had been trained, in order to learn the use of ours. The motive that has encouraged them has not been any hope of finding an experimental solution of any of the ultimate problems of philosophy, but the conviction that, inasmuch as the relation between mental stimuli and the mental processes which they awaken is of the same order with the relation between every other vital process and its specific determinant, the only hope of ascertaining its nature must lie in the employment of the same methods of comparative measurement which the biologist uses for similar purposes. Not that there is necessarly anything scientific in mere measurement, but that measurement affords the only means by which it can be determined whether or not the same conformity in the relation between stimulus and reaction which we have accepted as the fundamental characteristic of life is also to be found in mind, notwithstanding that mental processes have no known physical concomitants.

The results of experimental psychology tend to show that it is so, and consequently that in so far the processes in question are as truly functions of organism as the contraction of a muscle, or as the changes produced in the retinal pigment by light.

I will make no attempt even to enumerate the special lines of inquiry which during the last decade have been conducted with such vigor in all parts of the world, all of them traceable to the influence of the Leipzig school; but will content myself with saying that the general purpose of these investigations has been to determine with the utmost attainable precision the nature of psychical relations. Some of these investigations begin with those simpler reactions which more or less resemble those of an automatic mechanism, proceeding to those in which the resulting action or movement is modified by the influence of auxiliary or antagonistic conditions, or changed by the simultaneous or antecedent action on the reagent of other stimuli, in all of which cases the effect can be expressed quantitatively; others lead to results which do not so readily admit of measurement.

In pursuing this course of inquiry the physiologist finds himself as he proceeds more and more the *coadjutor* of the psychologist, less and less his *director*; for whatever advantage the former may have in the mere *technique* of observation, the things with which he has to do are revealed only to introspection, and can be studied only by methods which lie outside of his sphere. I might in illustration of this refer to many recent experimental researches—such, for example, as those by which it has been sought to obtain exact data as to the physiological concomitants of pleasure and of pain, or as to the influence of weari-

* Weber's researches were published in Wagner's *Handworterbuch*, I think, in 1849.

ness and recuperation, as modifiers of psychological reactions. Another outwork of the mental citadel which has been invaded by the experimental method is that of memory. Even here it can be shown that in the comparison of transitory as compared with permanent memory—as, for example, in the getting off by heart of a wholly uninteresting series of words, with subsequent oblivion and reacquisition—the labor of acquiring and reacquiring may be measured, and consequently the relation between them; and that this ratio varies according to a simple numerical law.

I think it not unlikely that the only effect of what I have said may be to suggest to some of my hearers the question, What is the use of such inquiries? Experimental psychology has, to the best of my knowledge, no technical application. The only satisfactory answer I can give is that it has exercised, and will exercise in future, a helpful influence on the science of life.

Every science of observation, and each branch of it, derives from the peculiarities of its methods certain tendencies which are apt to predominate unduly. We speak of this as specialization, and are constantly striving to resist its influence. The most successful way of doing so is by availing ourselves of the counteracting influence which two opposite tendencies mutually exercise when they are simultaneous. He that is skilled in the methods of introspection naturally (if I may be permitted to say so) looks at the same thing from an opposite point of view to that of the experimentalist. It is, therefore, good that the two should so work together that the tendency of the experimentalist to imagine the existence of mechanism where none is proved to exist—of the psychologist to approach the phenomena of mind too exclusively from the subjective side—may mutually correct and assist each other.

PHOTOTAXIS AND CHEMIOTAXIS.

Considering that every organism must have sprung from a unicellular ancestor, some have thought that unless we are prepared to admit a deferred epigenesis of mind, we must look for psychical manifestations even among the lowest animals, and that as in the protozoon all the vital activities are blended together, mind should be present among them not merely potentially but actually, though in diminished degree.

Such a hypothesis involves ultimate questions which it is unnecessary to enter upon: it will, however, be of interest in connection with our present subject to discuss the phenomena which served as a basis for it—those which relate to what may be termed the behavior of unicellular organisms and of individual cells, in so far as these last are capable of reacting to external influences. The observations which afford us most information are those in which the stimuli employed can be easily measured, such as electrical currents, light, or chemical agents in solution.

A single instance, or at most two, must suffice to illustrate the influence of light in directing the movements of freely moving cells, or, as it is termed, phototaxis. The rod-like purple organism called by Engelmann *Bacterium photometricum** is such a light lover that if you place a drop of water containing these organisms under the microscope, and focus the smallest possible beam of light on a particular spot in the field, the spot acts as a light trap and becomes so crowded with the little rodlets as to acquire a deep port wine color. If instead of making his trap of white light, he projected on the field a microscopic spectrum, Engelmann found that the rodlets showed their preference for a spectral color, which is absorbed when transmitted through their bodies. By the aid of a light trap of the same kind, the very well-known spindle-shaped and flagellate cell of Euglena can be shown to have a similar power of discriminating color, but its preference is different. This familiar organism advances with its flagellum forward, the sharp end of the spindle having a red or orange eye point. Accordingly, the light it loves is again that which is most absorbed—viz., the blue of the spectrum (line F).

These examples may serve as an introduction to a similar one in which the directing cause of movement is not physical but chemical. The spectral light trap is used in the way already described; the organisms to be observed are not colored, but bacteria of that common sort which twenty years ago we used to call *Bacterium termo*, and which is recognized as the ordinary determining cause of putrefaction. These organisms do not care for light, but are great oxygen lovers. Consequently, if you illuminate with your spectrum a filament of a confervoid alga, placed in water containing bacteria, the assimilation of carbon and consequent disengagement of oxygen is most active in the part of the filament which receives the red rays (B to C). To this part, therefore, where there is a dark band of absorption, the bacteria which want oxygen are attracted in crowds. The motive which brings them together is their desire for oxygen. Let us compare other instances in which the source of attraction is food.

The plasmodia of the myxomycetes, particularly one which has been recently investigated by Mr. Arthur Lister,† may be taken as a typical instance of what may be called the chemical allurement of living protoplasm. In this organism, which in the active state is an expansion of labile living material, the delicacy of the reaction is comparable to that of the sense of smell in those animals in which the olfactory organs are adapted to an aquatic life. Just as, for example, the dog fish is attracted by food which it cannot see, so the plasmodium of Badhamia becomes aware, as if it smelled it, of the presence of its food—a particular kind of fungus. I have no diagram to explain this, but will ask you to imagine an expansion of living material, quite structureless, spreading itself along a wet surface; that this expansion of transparent material is bounded by an irregular coast line; and that somewhere near the coast there has been placed a fragment of the material on which the Badhamia feeds. The presence of this bit of *Stereum* produces an excitement at the part of the plasmodium next to it. Toward this center of activity streams of living material converge. Soon the afflux leads to an outgrowth of the plasmodium, which in a few minutes advances toward the desired fragment, envelops and incorporates it.

May I give you another example also derived from the physiology of plants? Very shortly after the publication of Engelmann's observations of the attraction of bacteria by oxygen, Pfeffer made the remarkable discovery that the movements of the antherozoids of ferns and of mosses are guided by impressions derived from chemical sources, by the allurement exercised upon them by certain chemical substances in solution—in one of the instances mentioned by sugar, in the other by an organic acid. The method consisted in introducing the substance to be tested, in any required strength, into a minute capillary tube closed at one end, and placing it under the microscope in water inhabited by antherozoids, which thereupon showed their predilection for the substance, or the contrary, by its effect on their movements. In accordance with the principle followed in experimental psychology, Pfeffer* made it his object to determine, not the relative effects of different doses, but the smallest perceptible increase of dose which the organism was able to detect, with this result—that, just as in measurements of the relation between stimulus and reaction in ourselves we find that the sensational value of a stimulus depends, not on its absolute intensity, but on the ratio between that intensity and the previous excitation, so in this simplest of vital reagents the same so-called psycho-physical law manifests itself. It is not, however, with a view to this interesting relation that I have referred to Pfeffer's discovery, but because it serves as a center around which other phenomena, observed alike in plants and animals, have been grouped. As a general designation of reactions of this kind Pfeffer devised the term chemotaxis, or, as we in England prefer to call it, chemiotaxis. Pfeffer's contrivance for chemiotactic testing was borrowed from the pathologists, who have long used it for the purpose of determining the relation between a great variety of chemical compounds or products and the colorless corpuscles of the blood. I need, I am sure, make no apology for referring to a question which, although purely pathological, is of very great biological interest—the theory of the process by which, not only in man, but also, as Metschnikoff has strikingly shown, in animals far down in the scale of development, the organism protects itself against such harmful things as, whether particulate or not, are able to penetrate its framework. Since Cohnheim's great discovery in 1867 we have known that the central phenomenon of what is termed by pathologists *inflammation* is what would now be called a chemiotactic one; for it consists in the gathering together, like that of vultures to a carcass, of those migratory cells which have their home in the blood stream and in the lymphatic system, to any point where the living tissue of the body has been injured or damaged, as if the products of disintegration which are set free where such damage occurs were attractive to them.

The fact of chemiotaxis, therefore, as a constituent phenomenon of the process of inflammation, was familiar in pathology long before it was understood. Cohnheim himself attributed it to changes in the channels along which the cells moved, and this explanation was generally accepted, though some writers, at all events, recognized its incompleteness. But no sooner was Pfeffer's discovery known than Leber,† who for years had been working at the subject from the pathological side, at once saw that the two processes were of similar nature. Then followed a variety of researches of great interest, by which the importance of chemiotaxis in relation to the destruction of disease-producing microphytes was proved by that of Buchner ‡ on the chemical excitability of leucocytes being among the most important. Much discussion has taken place, as many present are aware, as to the kind of wandering cells, or leucocytes, which in the first instance attack morbific microbes, and how they deal with them. The question is not by any means decided. It has, however, I venture to think, been conclusively shown that the process of destruction is a chemical one, that the destructive agent has its source in the chemiotactic cells—that is, cells which act under the orders of chemical stimuli. Two Cambridge observers, Messrs. Kanthack and Hardy, § have lately shown that, in the particular instance which they have investigated, the cells which are most directly concerned in the destruction of morbific *bacilli*, although chemiotactic, do not possess the power of incorporating bacilli or particles of any other kind. While, therefore, we must regard the relation between the process of devitalizing and that of incorporating as not yet sufficiently determined, it is now no longer possible to regard the latter as essential to the former.

There seems, therefore, to be very little doubt that chemiotactic cells are among the agents by which the human or animal organism protects itself against infection. There are, however, many questions connected with this action which have not yet been answered. The first of these are chemical ones—that of the nature of the attractive substance and that of the process by which the living carriers of infection are destroyed. Another point to be determined is how far the process admits of adaptation to the particular infection which is present in each case, and to the state of liability or immunity of the infected individual. The subject is therefore of great complication. None of the points I have suggested can be settled by experiments in glass tubes such as I have described to you. These serve only as indications of the course to be followed in much more complicated and difficult investigations—when we have to do with acute diseases as they actually affect ourselves or animals of similar liability to ourselves, and find ourselves face to face with the question of their causes.

It is possible that many members of the association are not aware of the unfavorable—I will not say discreditable—position that this country at present occupies in relation to the scientific study of this great subject—the causes and mode of prevention of infectious diseases. As regards administrative efficiency in matters relating to public health England was at one time far ahead of all other countries, and still retains its superiority; but as regards scientific knowledge we are, in this subject as in others, content to borrow from our neighbors. Those who desire either to learn the methods of research or to carry out scientific inquiries, have to go to Berlin, to Munich, to Breslau, or to the Pasteur Institute in Paris, to obtain what England ought long ago to have provided. For to us, from the spread of our race all over the world, the prevention of acute infectious diseases is more important than to any other nation. At the beginning of this address I urged the claims of pure science. If I could, I should feel inclined to speak even more strongly of the application of science to the discovery of the causes of acute diseases. May I express the hope that the effort which is now being made to establish in England an institution for this purpose, not inferior in efficiency to those of other countries, may have the sympathy of all present? And now may I ask your attention for a few moments more to the subject that more immediately concerns us?

CONCLUSION.

The purpose which I have had in view has been to show that there is one principle—that of adaptation—which separates biology from the exact sciences, and that in the vast field of biological inquiry the end we have is not merely, as in natural philosophy, to investigate the relation between the phenomenon and the antecedent and concomitant conditions on which it depends, but to possess this knowledge in constant reference to the interest of the organism. It may perhaps be thought that this way of putting it is too teleological, and that in taking, as it were, as my text this evening so old-fashioned a biologist as Treviranus, I am yielding to a retrogressive tendency. It is not so. What I have desired to insist on is that *organism* is a fact which encounters the biologist at every step in his investigations; that in referring to it any general biological principle, such as adaptation, we are only referring it to itself, not explaining it; that no explanation will be attainable until the conditions of its coming into existence can be subjected to experimental investigation, so as to correlate them with those of processes in the non-living world.

Those who were present at the meeting of the British Association at Liverpool will remember that then, as well as at some subsequent meetings, the question whether the conditions necessary for such an inquiry could be realized was a burning one. This is no longer the case. The patient endeavors which were made about that time to obtain experimental proof of what was called *abiogenesis*, although they conduced materially to that better knowledge which we now possess of the conditions of life of bacteria, failed in the accomplishment of their purpose. The question still remains undetermined; it has, so to speak, been adjourned *sine die*. The only approach to it lies at present in the investigation of those rare instances in which, although the relations between a living organism and its environment cease as a watch stops when it has not been wound, these relations can be re-established—the process of life reawakened—by the application of the required stimulus.

I was also desirous to illustrate the relation between physiology and its two neighbors on either side, natural philosophy (including chemistry) and psychology. As regards the latter, I need add nothing to what has already been said. As regards the former, it may be well to notice that although physiology can never become a mere branch of applied physics or chemistry, there are parts of physiology wherein the principles of these sciences may be applied directly. Thus, in the beginning of the century, Young applied his investigations as to the movements of liquids in a system of elastic tubes, directly to the phenomena of the circulation; and a century before, Borelli successfully examined the mechanisms of locomotion and the action of muscles, without reference to any excepting mechanical principles. Similarly, the foundation of our present knowledge of the process of nutrition was laid in the researches of Bidder and Schmidt, in 1851, by determinations of the weight and composition of the body, the daily gain of weight by food or oxygen, the daily loss by the respiratory and other discharges, all of which could be accomplished by chemical means. But in by far the greater number of physiological investigations, both methods (the physical or chemical and the physiological) must be brought to bear on the same question—to co-operate for the elucidation of the same problem. In the researches, for example, which during several years have occupied Prof. Bohr, of Copenhagen, relating to the exchange of gases in respiration, he has shown that factors purely physical—namely, the partial pressure of oxygen and carbon dioxide in the blood which flows through the pulmonary capillaries—are, so to speak, interfered with in their action by the "specific energy" of the pulmonary tissue, in such a way as to render this fundamental process, which, since Lavoisier, has justly been regarded as one of the most important in physiology, much more complicated than we for a long time supposed it to be. In like manner Heidenhain has proved that the process of lymphatic absorption, which before we regarded as dependent on purely mechanical causes—*i. e.*, differences of pressure—is in great measure due to the specific energy of cells, and that in various processes of secretion the principal part is not, as we were inclined not many years ago to believe, attributable to liquid diffusion, but to the same agency. I wish that there had been time to have told you something of the discoveries which have been made in this particular field by Mr. Langley, who has made the subject of "specific energy" of secreting cells his own. It is in investigations of this kind, of which any number of examples could be given, in which vital reactions mix themselves up with physical and chemical ones so intimately that it is difficult to draw the line between them, that the physiologist derives most aid from whatever chemical and physical training he may be fortunate enough to possess.

There is, therefore, no doubt as to the advantages which physiology derives from the exact sciences. It could scarcely be averred that they would benefit in anything like the same degree from closer association

* Engelmann, "Bacterium photometricum," *Onderzoek. Physiol. L. b. Utrecht*, vol. vii., p. 200; also Ueber Licht- u. Farbenperception niederster Organismen, *Pflüger's Arch.*, vol. xxix., p. 387.

† Lister, "On the Plasmodium of *Badhamia utricularis, etc.*" *Annals of Botany*, No. 5, June, 1888.

* Pfeffer, *Untersuch. a. d. botan. Institute z. Tubingen*, vol. I., part 3, 1884.

† Leber, "Die Anhaufung der Leucocyten am Orte des Entzundungsreizes," etc., *Die Entstehung der Enzundung*, etc., pp. 423-464, Leipzig, 1891.

‡ Buchner, "Die chem. Reizbarkeit der Leucocyten," etc., *Berliner klin. Woch.*, 1890, No. 17.

§ Kanthack and Hardy, "On the Characters and Behavior of the Wandering Cells of the Frog." Proceedings of the Royal Society, vol. lii., p. 267.

with the science of life. Nevertheless, there are some points in respect of which that science may have usefully contributed to the advancement of physics or of chemistry. The discovery of Graham as to the characters of colloid substances, and as to the diffusion of bodies in solution through membranes, would never have been made had not Graham "plowed," so to speak, "with our heifer." The relations of certain coloring matters to oxygen and carbon dioxide would have been unknown, had no experiments been made on the respiration of animals and the assimilative process in plants; and, similarly, the vast amount of knowledge which relates to the chemical action of ferments must be claimed as of physiological origin. So also there are methods, both physical and chemical, which were originally devised for physiological purposes. Thus the method by which meteorological phenomena are continuously recorded graphically originated from that used by Ludwig (1847) in his "Researches on the Circulation;" the mercurial pump, invented by Lothar Meyer, was perfected in the physiological laboratories of Bonn and Leipzig; the rendering the galvanometer needle aperiodic by damping was first realized by Du Bois-Reymond—in all of which cases invention was prompted by the requirements of physiological research.

Let me conclude with one more instance of a different kind, which may serve to show how, perhaps, the wonderful ingenuity of contrivance which is displayed in certain organized structures—the eye, the ear or the organ of voice—may be of no less interest to the physicist than to the physiologist. Johannes Muller, as is well known, explained the compound eye of insects on the theory that an erect picture is formed on the convex retina by the combination of pencils of light received from different parts of the visual field through the eyelets (ommatidia) directed to them. Years afterward it was shown that in each eyelet an image is formed which is reversed. Consequently, the mosaic theory of Muller was for a long period discredited on the ground that an erect picture could not be made up of "upside-down" images. Lately the subject has been reinvestigated, with the result that the mosaic theory has regained its authority. Prof. Exner* has proved photographically that behind each part of the insect's eye an erect picture is formed of the objects toward which it is directed. There is, therefore, no longer any difficulty in understanding how the whole field of vision is mapped out as consistently as it is imaged on our own retina, with the difference, of course, that the picture is erect. But behind this fact lies a physical question—that of the relation between the erect picture which is photographed and the optical structure of the crystal cones which produce it—a question which, although we cannot now enter upon it, is quite as interesting as the physiological one.

With this history of a theory which, after having been for thirty years disbelieved, has been reinstated by the fortunate combination of methods derived from the two sciences, I will conclude. It may serve to show how, though physiology can never become a part of natural philosophy, the questions we have to deal with are cognate. Without forgetting that every phenomenon has to be regarded with reference to its useful purpose in the organism, the aim of the physiologist is not to inquire into final causes, but to investigate processes. His question is ever How, rather than Why.

May I illustrate this by a simple, perhaps too trivial, story, which derives its interest from its having been told of the childhood of one of the greatest natural philosophers of the present century?† He was even then possessed by that insatiable curiosity which is the first quality of the investigator; and it is related of him that his habitual question was "What is the go of it?" and if the answer was unsatisfactory, "What is the particular go of it?" That North Country boy became Prof. Clerk Maxwell. The questions he asked are those which in our various ways we are all trying to answer.

PICTURE TAKING AT THE WORLD'S COLUMBIAN EXPOSITION.

How many objects of interest may be photographed at the Fair, and the peculiar sights one sees there, are very aptly described by Mr. Carl C. Koerner, Jr., in the *American Amateur Photographer* as follows:

I think I am safe in saying that Midway Plaisance, that portion of the World's Fair grounds upon which are grouped, in successive order, the villages and inhabitants of the nations of the globe, will be the most attractive portion to the average camera-fiend with his weapon. Here are exact representations of the Asiatic and African, as well as Dutch, Irish, German and Austrian villages of Europe, and with the exception of the immensity and grandeur of the exterior of the Exhibition buildings, this was to me the most interesting section of the grounds. To be able to add to my album photos of these different nations, clothed as they are in their exact national dress, presented to me most rare and gratifying possibilities, and as it is quite expensive to carry a camera into the Fair grounds, my advice to my amateur friends would be to pay more attention to such scenes of life, etc., which I believe will be far more interesting souvenirs than photographs of the Exhibition buildings.

By Carl C. Koerner, Jr.

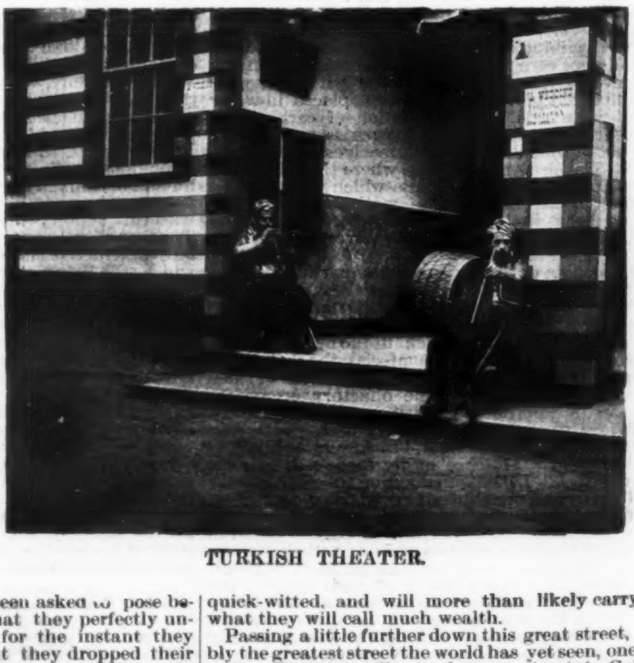
DRUMMING UP PATRONS—STREET IN CAIRO.

My first attempt in the Plaisance was made upon a couple of Javanese, who were working on one of their odd-shaped little huts, made of bamboo and alang-alang grass. I tried my best to attract their attention, and when I finally succeeded and pointed my camera toward them, two more frightened-looking beings I never beheld in my life. As it was quite dark, it was necessary for me to use my largest diaphragm and slowest shutter, and I motioned to them to remain perfectly quiet. This was, however, needless, as they stood as if spellbound, not daring to move a muscle, and the moment I took my instrument off them they began gesticulating and jabbering at a great rate. I would give a good deal to know what these odd little fellows imagined I was doing to them, and from their looks I should say that they thought I was going to exterminate them. These Javanese are a very peculiar-looking lot of people, rather short of stature, with large, round heads, which they have wrapped up in huge cloths resembling turbans, and I imagine that the climate of Chicago is not particularly tasteful to them, coming as they do from a very torrid zone. Their skin is a regular coffee color. The word "coffee," I should add, is the only English they understand, and they will direct you to a pavilion across the road from their village, where the genuine beverage is being served.

I next attempted to photograph a couple of Turks who were lugging a Sedan chair. It appeared very evident that they had already been askea ω pose before some photographer, and that they perfectly understood the uses of a camera, for the instant they saw me preparing my instrument they dropped their chair and ran toward me jabbering something in Turkish, repeating over and over the words "fifteen cents." I began to understand that if I wished to photograph them, they would pose for the sum of fifteen cents, and without further argument I assented. And quite a pose they did make, standing with heads and shoulders erect, with one foot a little in advance of the other as if in the act of walking. I made the exposure, and reached in my pocket for the required amount, and a crowd of Turks who were standing near gathered around me; not finding the exact change, I produced my wallet, in which I had quite a pile of small bills. The shout that went up from that crowd at the sight of those ones and twos, which they probably imagined was a vast sum, was not encouraging to say the least, and as I glanced around me at those dark grinning faces, I began to realize how foolish in me to thus display my money before them. I drew out one of the dollar bills and tried to explain to the fellow with whom I had bargained to give me eighty-five cents and I would give him the bill. This he was unable to understand and demanded that I give him the entire bill for his services, his companions behind emphasizing his request. At this moment a Turk came up who could understand a little English, and I explained matters to him, whereupon he produced four quarters, gave me three and one to my subject, he taking the bill. All things considered, I got off very luckily. These Turks present a very picturesque appearance in their gayly colored costumes. Their trousers are of a heavy cloth, mostly red and blue, fitting their limbs closely until above the knee, where they begin to widen very abruptly and they bag, presenting a peculiar appearance as they stride along. They wear little short coats of some gay color, and on their heads they wear a little red fez.

In this same village is a Turkish theater, and I thought a snap-shot of the entrance, where two gayly attired musicians were playing on some peculiar-looking instruments, would be a very interesting souvenir. One of them was playing on an instrument greatly resembling a clarinet and a Swiss shepherd's horn, having that same woful sound; the other was beating on an odd-looking drum, a little smaller than our ordinary bass drum. I succeeded in attracting the attention of the last named, but the other fellow played right on, with cheeks extended, apparently never stopping to breathe. As a whole, these Turks are very quick-witted, and will more than likely carry home what they will call much wealth.

THE SEDAN CHAIR.



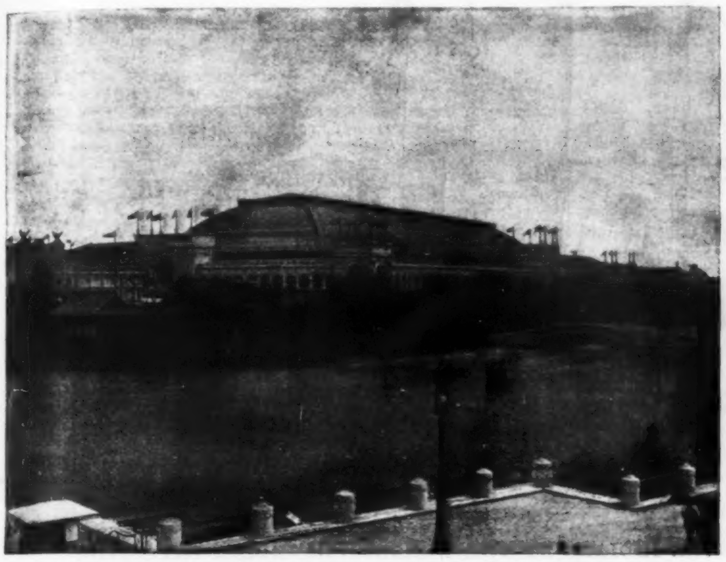
TURKISH THEATER.

Passing a little further down this great street, probably the greatest street the world has yet seen, one comes to the Egyptian village, where a street in Cairo has been represented. This village has just been thrown open to the public, being not quite complete at the time of my first visit. I inquired of one of the over-

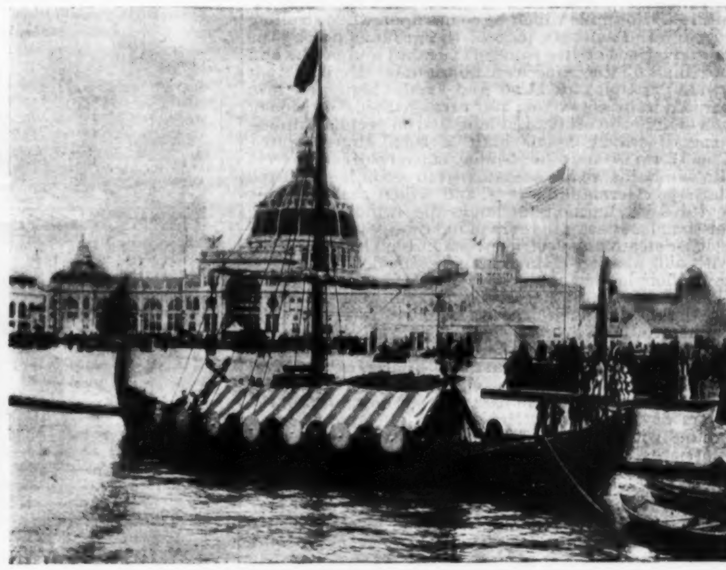
* Exner, "Die Physiologie der facettirten Augen von Krebsen u. Insecten," Leipzig, 1891.

† "Life of Clerk Maxwell" (Campbell and Garnett), p. 28.

seers if it would be possible for me to make a group of three or four of these Egyptians, and upon explaining to them what I wanted, three of them agreed to pose for the sum of one dollar. As this was exorbitant, I refused to pay it, and was about to go on, when they came down to ten cents. This is a characteristic of almost all of these Asiatic nationalities, for they demand unreasonable prices for their trinkets, money and wares, and rather than let you go, will reduce their price anywhere from one to two hundred per cent. As the guard would not allow me to go into the village, nor the Egyptians to come out, I was unable to make this photograph, much to my regret. I was about to pass on, when the over-



THE WOODED ISLAND AND LIBERAL ARTS BUILDING.



THE VIKING SHIP.

seer, who was an Englishman, told me to wait a minute and he would bring me a fellow who would pose for nothing and I could take a shot at him through the gate. He returned immediately, followed by a Nubian of the blackest sort. The home of these people is in the Nile valley, just south of Egypt, into which country they have migrated in considerable numbers, where they act as soldiers, servants, and dealers in small wares; being particularly noted for their honesty and good morals. This fellow was dressed very scantily in a pair of short white trousers and coat, his arms and legs being entirely bare, the sight of which made me shiver, as there was quite a penetrating breeze blowing at the time. He, too, had already been operated upon, and seemed to think he appeared to best advantage while going through some strange dance, and began waving his arms and jumping about most ludicrously, at the same time chanting some strange Egyptian words. The guard again interfered, and not relishing an arrest, which these Reubens are at all times far too anxious to make, I was again compelled to lose an exposure. I was much disappointed, as this fellow would have made an excellent subject, there being such contrast between his extremely dark skin and white clothes, and handing him a small coin and thanking him for the amusement he had afforded us, we passed on down the street looking for more spoil.

A short distance off I saw approaching a party of gorgeously attired Arabians, probably of a high and well educated class. They wear long white gowns

By Carl C. Koerner, Jr.

SOUTH FROM WOODED ISLAND—ADMINISTRATION BUILDING.

By Carl C. Koerner, Jr.

BLIND MAN'S BUFF.

extending to the ankles, over which are highly colored coats, beautifully embroidered. I got out my camera, intending to lay for them and shoot them as they passed by. One of the party, a bright-eyed youth, espied me, and followed by his companions rushed toward me and demanded by gesticulating that I put my camera up, and not caring to provoke them, I complied. The Arabians, while very intelligent in appearance, are not the most amiable-looking people I ever saw; they are, however, as a nation very polite, and an explanation was offered me by one of the party who could speak English quite creditably. He said that his people believe a camera to be an "evil eye," and that to perpetuate their facsimiles would make it impossible for them to enter heaven. If this is really the case, these poor people have my sympathy, as it is very probable that more than one innocent amateur has already made their photographs.

My advice to my fellow amateurs would be, not to attempt to photograph any of these strange people until you are sure they understand exactly what you are aiming to do.

Mr. F. C. Beach, in the same magazine, has an interesting article on "Glimpses of the Fair through a Camera," from which we make the following extracts:

It is the opinion of every amateur who has visited the World's Fair that there are more opportunities for making interesting and picturesque photographs within a given area than in almost any other spot in the world. It is a paradise for the amateur photographer. The buildings are so massive and well proportioned, with ample plazas and spaces in front of them, that they are easy to take, while the variety in architecture invariably makes a pleasing effect.

In the illustration taken from the balcony of the Woman's building, looking southeast, entitled "The Wooded Island and Liberal Arts Building," an idea of the immensity of the latter is readily given, but it must be actually seen to be fully comprehended. The buildings on the island were built by the Japanese and are to belong to the city of Chicago after the Fair closes. They are substantially built and the interior decorations are very beautiful and quaint. Each building represents some special period in Japanese history. The United States government building may be observed beyond the island, on the left. Two fine massive statues of deer are at the end of the bridge on the right connecting the island with the main land, their white color standing out in strong relief against the dark foliage of the island.

In another illustration, made by Mr. Carl C. Koerner, Jr., is a view from the Wooded Island looking south over the connecting bridge toward the Administration building, whose gilded dome looms up above all the other buildings, and at night, illuminated by hundreds of incandescent lamps, is a very conspicuous object. On the left is the facade of the Electricity building, and on the right the Mining building.

From the north balcony of the Electricity building a very excellent view of the Wooded Island and lagoon may be had, having the horizon in the distance broken by the many domes and turrets of the Foreign, State and Art buildings.

A most interesting and novel staff sculpture is that entitled "Blind Man's Buff," by C. Richards, in front of the Illinois building.

Many of the foreign buildings present peculiarities that make them, also, attractive objects for the camera, and there are numerous historical things worth taking. All the departments of the United States government are concentrated around or in the neighborhood of the Government building, and afford much material of unusual interest to be taken with the camera. The life saving drill, carried on every day about two o'clock in the afternoon, is a most interesting object lesson of the work of that important branch of the government, and is worth photographing. It is performed near where the brick-built man-of-war or cruiser Illinois is stationed, and views may be made from her deck or from the shore.

Moored close to the dock, and parallel with the shore, near the Illinois, is an exact copy of the famous Viking ship that was discovered in a mound at Gokstad, in Norway, in 1880. Our illustration gives an excellent idea of the vessel; the prow is adorned by a colossal finely carved dragon's head, and the stern with a dragon's tail. The round shields on the outside are painted in different colors, and between them are places for oars, which are used when the wind fails. The rigging is very simple, one mast and one yard, which can be taken down in case of necessity. Benches are arranged inside for the men manning the oars, and in the rear is a sort of chair or throne for the captain. The rudder is carried on the right side of the vessel. It was in one of these vessels that Lief, the son of Erik the Red, is claimed to have discovered Vinland, Markland and Helland on the coast of Massachusetts years before Columbus sailed. Captain Magnus Andersen sailed this vessel from the coast of Norway last spring to New York, and it was brought through the lakes to Chicago.

In the picture, just back of the bow of the Viking, is seen on the shore armor plates which have stood severe tests. Directly back of these is a low building with a turret on one end—a reproduction of the United States Naval Observatory. On the extreme right is the rear of the Life Saving Station; in the center is the dome of the Government building. The Weather

Bureau building is just behind the pole bearing the large United States flag. A glimpse of the Liberal Arts building is to be seen on the extreme left. In front of the Government building is a beautiful greensward, which is a great relief to the white of the other buildings.

A visit to the Fair is most instructive from whatever point of view it is considered, and no one can see it without coming away with enlarged ideas and a true sense of the immensity of our country and its resources.

THE WORLD'S COLUMBIAN EXPOSITION.

The Exhibit of Windmills.—Nothing surprises the European visitor at the Fair more than the queer exhibit of windmills which he comes upon when strolling through the southern part of the grounds among the reproductions of the ruins of Yucatan and of the cliff dwellings of the American aborigines. Here he finds windmills that are large and small, high and low, painted in bright colors, and arranged side by side or one behind the other, and mounted on peculiar frames, some of which are as high as small church spires. Their form is new and strange, entirely different from the windmills we are accustomed to see in Holland and the Low German districts, and which are charming features of a harmonious landscape—windmills which, for the most part, are relics of old times when there was neither steam nor electricity, and which are connected with old, weather-stained houses, sails being stretched over their ladder-like arms. The Knight of the Sad Countenance would scarcely recognize the enemy of the Spanish Mancha here in the new world.

But windmills are as necessary in America as in our old world, if not more so, although they are used for different purposes. On the great prairies of the West and on the table lands among the Rocky Mountains weeks and months often pass without any rainfall, the rivers dry up, and settlers are left on bare, woodless ground without water. The railroads have not even the necessary supply for their locomotives, and in many parts of the country are obliged to carry water with them. There is no lack of wind, however, which frequently blows with such force as to be a real hurricane, sweeping everything from the level surface of the ground. The settlers make one element work against the other, air against water, for they dig wells in the prairies that are deep enough to strike water, and the windmills which they place over the bores pump the water up. The windmills are not used "on the other side," as with us, for grinding corn and for such purposes, and therefore their form is different. They are not connected with buildings, but stand by themselves, and consist of high frames, generally of iron, on the tops of which little, light, many-armed wheels are mounted. The height of the framework depends on the position of the windmill, whether it stands on the level prairie or in a valley or ravine; in the latter case the frame must be high, to reach the current of the wind. The little wheels turn quickly on their axles and raise the pump pistons many times in a minute. The appearance of a single one of these windmills is odd enough, but how much more strange is a whole assemblage of them, as seen at the Exposition!

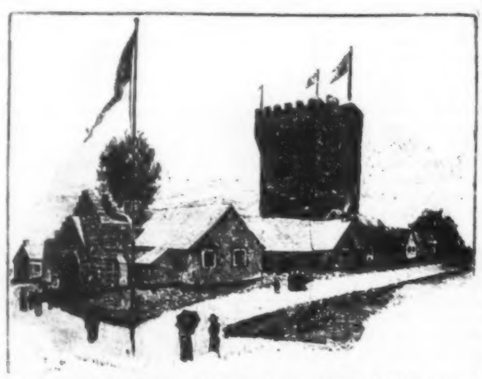
THE WORLD'S COLUMBIAN EXPOSITION—THE EXHIBIT OF WINDMILLS.

The Vancouver Indians.—The southeastern part of Jackson Park, inclosing the small lake called South Pond, is devoted to anthropological exhibits. It seems rather doubtful whether a place should be accorded to anthropology in a modern exposition which has for its object a comparison of the progress of the end of the nineteenth century with the civilization of the fifteenth century. Nevertheless, the valuable collections which the celebrated Smithsonian Institution of Washington has arranged in a special building, and the separate exhibits arranged about this building, are very interesting. Here have been erected copies, in the natural size, of ruins found in Yucatan, chiefly in Uxmal, and here, in a high artificial rock, can be seen fac-similes of the homes of the cliff dwellers of southern Colorado and Arizona, and near these structures, on the shore of the South Pond, are huts of the Vancouver Indians. These Indians and the tribes that live farther north, the Chinooks, Haydahs, Babinehs, and others, bear a strange resemblance to the Malays and Polynesians, a resemblance which also finds expression in their manners and customs, and indicates that they have mixed with the western races, if they are not absolutely descended from them. This resemblance is very noticeable in the company, consisting of about two dozen men and squaws in charge of the daughter of the chief, who occupy these huts. Before each hut is a so-called totem pole bearing the roughly carved animals and figures which form the coat of arms of the family living in the house. The grotesque faces and figures are smeared with colors, generally red and blue. These poles, which constitute the special pride of the occupants of the dwellings, are used only by the Indians of the Northwest.

A fire burns on the floor of earth in the center of the great dark room, the smoke passing slowly out through the roof. The beds of the Indians are arranged on the walls, one above the other, like the berths on shipboard; before them, on the ground, are spread skins of animals. On the carved and colored chests, which constitute the only furniture of these dwellings, lie the household utensils, spoons and cups cut out of horn, wooden hooks, paddles with round blades like great kitchen spoons, and bows and arrows. The red-skinned, narrow-eyed occupants themselves crouch on the skins, wrapped in gay-colored cloths and blankets, but these they have adopted only for the occasion, because I have seen them in British Columbia and on the adjacent islands wearing nothing but the breech clout. In the shallow water before these huts float a couple of canoes, made of logs that have been burned out and provided with high stems.

HUTS OF VANCOUVER INDIANS AT THE WORLD'S COLUMBIAN EXPOSITION.

The Vancouver Indians live mostly by fishing, and they are famous swimmers and boatmen. I saw them out on the open sea in their little boats many miles from their homes, even when the sea was very rough.



THE IRISH VILLAGE AT THE WORLD'S COLUMBIAN EXPOSITION.

The Irish Village.—With their inborn "modesty," the Irish, the most restless of the civilized peoples of the world, are represented by two villages instead of one in the Midway Plaisance, and to the larger of these is given the best place on the Midway, close to the Exposition grounds proper. A high tower, apparently gray with age, attracts the attention of the visitor while he is still at a distance. I had scarcely hoped to see on the shores of Lake Michigan so good a copy of this, the best preserved portion of the famous Blarney castle, so rich in legends, to which I made a pilgrimage years ago. The old steps of the tower are dangerous to life, and yet many unhappy creatures climb to the parapet to kiss the renowned Blarney stone, which is built into the wall up there. It was a happy thought of Lady Aberdeen, the wife of the English governor general of Canada, to have the Blarney tower built as the chief attraction to her Irish village; it has certainly been the means of attracting many visitors. The entrance to the village is a reproduction of the arched gate of the chapel of King Cormac on the Rock of Cashel, and beyond this is a facsimile of part of the interior of the Muckross Abbey. Then follow rows of small houses such as are seen in Irish villages, but the occupants of the originals in the Emerald Isle share them with the swine and fowls, while here each house is devoted to some branch of industry, such as spinning, weaving, lace making, making pottery, etc. Trim Irish girls in the national costume are busy with this work, and their pretty faces are, perhaps, as much of an attraction as the Blarney stone, which they have only to kiss in order to carry home with them rich Yankee husbands.—*Illustrirte Zeitung.*

GLYCIN AS A DEVELOPER FOR LANTERN PICTURES.

WE have recently been experimenting with some of the new developing agents for transparency work, and the following notes with regard to glycin may be of interest to our readers. Our attention was drawn to glycin as a possibly useful developer for lantern pictures, because in reports concerning it we had read that it would give images absolutely free from fog—and this we certainly found to be the case, although we rang the changes considerably in the matter of exposure.

The formula which we finally adopted was as follows:

Glycin	60 grs.
Potass. carb.	250 "
Potass. bromide	10 "
Water (distilled) to	10 oz.

The solution, we fancy, is not so energetic when first mixed as it is an hour or two later, and it keeps well if the bottle is full, but if an air space is left above the surface of the liquid, signs of oxidation quickly become apparent. Probably the best way to keep the developer in working order would be to employ a bottle with an arrangement for drawing off the liquid from below, while the surface has a protecting layer of oil. Such a bottle was devised years ago, when the ferrous-oxalate one-solution developer was first introduced.

As a result of many trials we have come to the con-

clusion that glycin—unless, possibly, it behaves differently in association with other salts—is not a serviceable *all-round* developer for lantern pictures. But, at the same time, it is a most valuable aid for obtaining clear pictures from negatives of a certain type. If the negative be even slightly fogged in the shadows—as the great majority of negatives are—the veil seems to offer an unwonted obstruction when this developer is used, and it is difficult to get those full tones which are so necessary in a good lantern picture. In the case of veiled distances the same objection applies—the foreground printing strongly, while all beyond is often invisible in the lantern pictures.

With a thin and clear-shadowed negative, on the other hand, it is different, for glycin will give with such a negative an admirable transparency on a gelatine plate. It is somewhat slow in action, and extra time must be allowed for the developer to act after the operation seems to be complete, or the worker will be disappointed with a too thin image when the plate comes from the fixing bath. The value of glycin will therefore be most felt by the lantern-slide producer if he sets aside his thin and ghostly negatives for treatment by it, leaving the normal and denser ones to yield up their images to the promptings of hydroquinone or pyro. With a suitable negative glycin gives a clear and beautifully soft picture, having a pleasing, warm black tone.—*Photo. News.*

SPONTANEOUS COMBUSTION.

AT the recent Nottingham meeting of the British Association, Professor Vivian B. Lewes, F.I.C., F.C.S., selected the above subject for his discourse.

The lecturer began by stating that, when an inflammable substance ignites or becomes incandescent without the application of fire or other apparent cause, it has been customary to speak of it as "spontaneous combustion"—a term which he thought he should be able to show does not correctly express the actions leading to this apparently mysterious result. He then proceeded to refer to the experiments carried out by Priestley and Lavoisier in the last century, which disposed of the theory then generally accepted, that every combustible body contained within itself the products of combustion, combined with something called "phlogiston," and that, when the substance was burnt, this phlogiston escaped—giving the flame or incandescence of combustion, while the products were set free. Lavoisier showed that air consisted of two gases—oxygen and nitrogen—and that anything which would burn in air would burn with still greater vigor in oxygen; while nitrogen alone instantly stopped the combustion of the bodies requiring air to enable them to burn. The enunciation of these truths by the great French philosopher was one of the most important steps in the history of science; but Professor Lewes pointed out that, with increase of knowledge, we find that we must still further widen our views with regard to combustion, and must take care not to fall into the error of looking upon those substances which will burn in air or oxygen as the only combustibles, and oxygen as the only supporter of combustion. These terms were, in fact, purely relative; and a substance which was looked upon as a combustible might, under altered conditions, become a supporter of combustion. Indeed, a body like coal gas, which burns in air or oxygen, would support in turn the combustion of air; and it could, he said, be experimentally shown that it was just as easy to have a flame of air burning in coal gas as, under ordinary conditions, to have a flame of coal gas burning in air. If all cases of combustion were carefully examined, it would be found that in them there was a body with certain definite properties of its own, uniting itself with something else to form what were called the "products of combustion," which were equal in weight to the sum of the weights of the two bodies uniting, and had characteristic properties differing from those of the original substances. This action might be termed one of chemical combination; and extended experiments showed that, in order to obtain a true conception of combustion, it must be looked upon as "the evolution of heat during chemical combination." In many instances, the process was so slow that the heat evolved escaped notice; and the action was then called "slow combustion." This was in all cases accelerated by increase of temperature; and the higher the temperature the more rapid became the chemical action. All combustible bodies at a certain degree of heat would undergo ignition. Then the temperature was reached at which slow combustion passed into ordinary combustion, with manifestation of flame or incandescence—the chemical combination being then so rapid that the heat evolved was manifest to the sight. A still greater increase in speed would in some cases bring about the most rapid form of combustion—viz., explosion. It was the change from the little noticeable slow combustion to ordinary combustion to which the term "spontaneous combustion" had been given.

Professor Lewes then passed on to consider special cases of spontaneous combustion. He pointed out that, when the combustible substance has a great affinity for oxygen, and at the same time a low point of ignition, spontaneous combustion will easily take place. Certain bodies have the power of absorbing many times their own volume of gases; and, in doing this, they not only give rise to a certain increase in temperature, due to the compression of the absorbed gas upon their surfaces or in their pores, but also to greater chemical activity of the gas so compressed. Carbon is one of those substances which possess to an extraordinary degree the power of attracting and condensing gases upon their surface; this power varying with the state of division of the particular form of carbon used. The charcoal obtained from dense forms of wood—such as box—exhibits this property to a high degree. The lecturer said there were several interesting points with regard to the spontaneous combustion of charcoal which called for more attention than had been devoted to them; and we therefore reproduce in full the portion of his discourse dealing with this subject, and that of the spontaneous ignition of coal which followed it.

It is self-evident, he said, that the more porous a body is, the greater amount of exposed surface will be available for the condensation of gases; and the great power which charcoal has of absorption is undoubtedly due to its great porosity. The temperature at which wood can be carbonized varies very considerably; and wood will begin to char—that is to say, will begin to be converted into charcoal—at temperatures very little above that of boiling water. Charcoal formed at this low temperature, however, still contains large quanties of hydrogen and hydrocarbons, and is not nearly so porous as charcoal made at a high temperature; and although the diminution in porosity makes it less susceptible to spontaneous combustion due to the heat produced by the condensation of gases, yet another cause which tends still more to dangerous rise of temperature comes into play. When a substance condenses oxygen upon its surface from the atmosphere, the gas is in a very chemically active condition, and will bring about chemical combination with considerable rapidity. For instance, if a piece of platinum foil is heated to redness, so as to drive off all gases from its surface, and is then allowed to cool until it ceases to be visibly red, and is held in a stream of mixed air and coal gas, or air and hydrogen, it again becomes red hot, owing to the chemical combination of these substances upon its surface—that is to say, it has been able to condense these gases together, and set up combustion. If charcoal is burnt at a high temperature, the carbon is in a dense condition, and resists to a considerable extent the setting up of chemical action by the oxygen condensed and absorbed in its pores. But if it has been formed at a low temperature, this condensed oxygen will rapidly act upon the hydrocarbons and hydrogen still remaining in mass, and will in this way raise the temperature to a dangerous point; and it is more than probable that very many unexplained fires have been brought about by beams and woodwork becoming charred in contact with flues and heating pipes. It has been experimentally determined that, when wood has been charred at 500° Fah., it will take fire spontaneously when the temperature is raised in the presence of air to 680°; and that, when wood has been carbonized at 260°, a temperature of 340° only is required for its spontaneous ignition. If a beam is in contact during the winter months with a heated flue, or even with steam pipes, it becomes carbonized upon its surface; and during the summer, when the flue or pipe is probably not at work, it absorbs air and moisture. During the next winter, it again becomes heated and further carbonized, while the moisture and air are driven out; leaving the pores in a condition eminently adapted for the absorption of more air as soon as the temperature is allowed to fall. In many cases, sufficient heat is generated to cause the charred mass to smoulder, and to burst into flame when air is freely admitted to it. In the case of charcoal burnt at a high temperature, it may be taken that the cause of heating is almost entirely physical; while in the low-burnt charcoal, it becomes chemical as well as physical. It is this chemical action which is the most dangerous, and acts in the majority of cases of spontaneous combustion.

The spontaneous ignition of coal has been the cause of an enormous number of serious accidents; and the earliest theory as to its cause was that it was due to the heat given out during the oxidation of the pyrites or "coal brasses," which are compounds of sulphur and iron, and are present in varying quantities in nearly all coal. This idea has held its ground nearly up to the present time, in spite of the researches of Dr. Richters, which some twenty years ago showed that the explanation was an erroneous one. Even earlier, in 1864, Dr. Percy pointed out that the cause of spontaneous ignition was probably the oxidation of the coal, and that the pyrites had but little to do with it. Pyrites is found in coal in several different forms—sometimes as a dark powder closely resembling coal itself, and in larger quantities in thin golden-looking layers in the cleavage of the coal; at others in masses and veins of considerable size. These masses, however, are very heavy, and are carefully picked out from the coal and utilized in various manufactures. The yellow pyrites, and even the dark varieties when in the crystalline form, remain practically unaltered, even after long exposure to moist air; but the amorphous and finely divided portions oxidize and effloresce with great rapidity. It is during this oxidation that the heat is supposed to be generated. Some coals that are very liable to spontaneous ignition only contain 0·8 per cent. of pyrites; and if we imagine this to be concentrated in one spot, instead of being spread over the whole mass, and to be oxidized in a few hours, the temperature would rise only a few degrees. Under ordinary circumstances, this would be practically inappreciable.

The oxidation of masses of pyrites under certain conditions gives rise to the formation of ferrous sulphate and sulphur dioxide, with liberation of sulphur; and one might easily imagine that this free sulphur, which has an igniting point of 250° C., would play an important part in the action, by lowering the point of ignition. This, however, could only happen with large masses of pyrites undergoing oxidation; and, with the small amount of pyrites in coal, supposing air were present in sufficient quantity to oxidize it, the sulphur formed would be converted into sulphur dioxide at temperatures as low as 60° C. This oxidation of sulphur at low temperatures is an action not generally known; but, in my experiments, I have found it takes place with considerable rapidity. The only way in which pyrites can assist the spontaneous ignition of coal is that when it oxidizes it swells, and splits up the coal; thus exposing fresh surfaces to the action of the atmospheric oxygen. I have carefully determined the igniting points of several kinds of coal, and find that cannel coal ignites at 698° Fah. (370° C.); Hartlepool coal, at 766° Fah. (408° C.); lignite coal, at 842° Fah. (450° C.); and Welsh steam coal, at 870° Fah. (477° C.) So that it is impossible for the small trace of pyrites scattered through a large mass of coal and slowly undergoing oxidation to raise the temperature to the necessary degree. When coal is heating, a distinctive and penetrating odor is evolved, which is the same as that noticed when wood is scorched; and the gases produced consist of nitrogen, water vapor, carbon dioxide, carbon monoxide, hydrocarbons of the paraffin series, and sulphureted hydrogen—the presence of the latter gas showing beyond doubt that oxidation of the sulphur has nothing to do with the action.

Ever since coal has been generally adopted as a fuel, it has been recognized that great care was necessary in the storing and shipment of masses exceeding 1,000 tons; and if the coal has been stored wet or in a broken state, firing or heating of the mass has frequently taken place. Much inconvenience and loss have been caused by this on shore; but the real danger has occurred during shipment. In consequence of this many a vessel has been lost with all hands, without any record of the calamity reaching shore. Owing to the greater facility for treating the coal when it becomes heated on shore in coal stores and gas works, absolute ignition only rarely takes place; and it is mainly from evidence contained in the case of coal cargoes that we learn most as to the causes which lead to it.

Coal is a substance of purely vegetable origin, formed out of contact with air, by long exposure to heat and pressure, from the woody fiber and resinous constituents of a monster vegetation which flourished long before the earth was inhabited by man. Coal, therefore, may be looked upon as a form of charcoal, which, having been formed at a temperature lower than that of the charcoal burner's heap, and under great pressure, is very dense, and still contains a quantity of these constituents which, in the ordinary burning, are driven off as wood naphtha, tar, etc. These bodies consist of compounds containing essentially carbon and hydrogen, together with a little oxygen and nitrogen, and form the volatile matter and hydrocarbons of the coal. Besides these, coal also contains certain mineral bodies, which were present in the fiber and sap of the original wood; and they form the ash which is left behind on the coal being burnt. These mineral substances consist almost entirely of gypsum or sulphate of lime, silica, and alumina, together with some oxide of iron, which gives the color to the reddish brown ash of many coals, and which has been formed by the decomposition of the pyrites in the original coal. The mineral constituents of coal are the only ones, with the exception of the pyrites, that do not play any part in the phenomena attending the heating and spontaneous ignition of coal; and we must therefore only regard the actions which take place when the carbon, hydrocarbons, and pyrites in freshly won coal come in contact with air and moisture.

Certain kinds of coal exhibit the same power of absorbing gases which charcoal has, although to a less degree. The absorptive power of new coal due to this surface attraction varies; but the least absorbent will take up one and a quarter times its own volume of oxygen, while in some coals more than three times their volume of the gas is absorbed. This causes a rise in temperature, and tends to increase the rate of the action which is going on; but it is rarely sufficient to bring about spontaneous ignition, as the fact that only about one-third of the amount of oxygen is absorbed by coal that is taken up by charcoal, and that the action is much slower, tends to prevent the temperature reaching the high ignition point of the coal.

All coal contains a certain proportion of hydrogen, with which some of the carbon is combined, together with the nitrogen and oxygen—forming the volatile matter in the coal. The amount of this volatile matter varies greatly. Anthracite contains the smallest quantity and cannel and shale the largest. When the carbon of the coal absorbs oxygen, the compressed gas becomes chemically very active, and soon commences to combine with the carbon and hydrogen of the bituminous portions—converting them into carbon dioxide and water vapor. As the temperature rises, this chemical activity increases; so that the heat generated by the absorption of the oxygen causes it to rapidly enter into chemical combination. This kind of chemical combination—oxidation—is always accompanied by heat; and this further rise of temperature helps the rapidity of oxidation, so that the temperature goes up steadily. This, taking place in a large mass of coal, which from physical causes is an admirable nonconductor, will often cause such heating of the mass that, if sufficient air can pass into the heap in order to continue the action, the igniting point of the coal will be reached. It has been suggested that very bituminous coals, such as cannel and shale, are liable to spontaneous ignition from the fact that heavy oils would exude from them on a rise of temperature; and that these, by oxidizing, might produce rapid heating. Experiment, however, shows that this is not the case, and that the heavy mineral oils have a decided effect in retarding heating.

We can now trace the actions which culminate in ignition. As soon as the coal is brought to bank, absorption of oxygen commences; but, except under rare conditions, the coal does not heat to any great extent, as the exposed surface is comparatively small, and the largeness of the masses allows of the air having free access to all parts, so keeping down the temperature. After the coal has been screened, and the large pieces of pyrites have been picked out, it is put in trucks. Here it begins to be broken up, owing to the many joltings and shuntings, and so offers a larger surface to the action of the air. When it has arrived at the ship it is further broken up by being shot down the tips or shoots; and more harm is done at this than at any other period, for the coal is broken by reason of the distance it has to fall, and it has to bear the impact of every succeeding load falling upon it. Consequently, it rapidly becomes slack; so that the under part of the ship load is a dense mass of small coal, which soon rises in temperature by reason of the large surface exposed to the air and the consequent absorption of oxygen. This sets up chemical combination between the oxygen taken in by the coal and the hydrocarbons, and in some cases culminates in combustion.

It is found that the mass of coal exercises a most important action in the liability to spontaneous combustion, as, although with 500 tons of coal to the cargo the cases amount to only about one-fourth of 1 per cent., when the bulk is increased to 2,000 tons they rise to 9 per cent. This is due to the fact that the larger the cargo, the more non-conducting material will there be to keep in the heat; and also to the fact that the breaking up of the coal and the exposing of fresh surfaces will, of course, increase with augmentation in mass. It is also found that coal cargoes sent to European ports rarely undergo spontaneous com-

bustion; while the number of cases rises to a startling extent in shipments made to Asia, Africa, and America. The result is partly due to the length of time the cargo is in the vessel; the absorption and oxidation being a comparatively slow process. But the main cause is the greater heat in the tropics, which causes the action to become more rapid. If statistics had been taken, most of the ships would have been found to have developed active combustion somewhere about the neighborhood of the Cape; the action fostered in the tropics having raised the temperature to the igniting point by that time.

Moisture has a most remarkable effect upon the spontaneous ignition of coal. The absorption of oxygen is at first retarded by external wetting; but after a time the presence of moisture accelerates the action of the absorbed oxygen upon the coal, and so causes a serious increase of heat. The researches of Cowper, Baker, Dixon, and others, have of late years so fully shown the important part which moisture plays in actions of this kind that it is now recognized as a most important factor. A very marked case of the influence of moisture came under my notice a few months ago. A ship took in a cargo of coal at a South Wales port; the weather being fine and dry while she was loading at the main hatch, but wet while she was taking in the coal at the after hatch. The result was that the temperature in a few days was uniformly about 10 degrees higher in the coal loaded wet than in the dry portion of the cargo; spontaneous ignition being the final result at the after hatch.

In order to prevent the spontaneous ignition of large masses of coal, it is manifest that every precaution should be taken, during loading or storing, to prevent crushing; and on no account must a large accumulation of small coal be allowed. Where possible, the depth of coal in the store should not exceed 6 to 8 feet; and under no conditions must steam-pipes or flues be allowed so near the mass of coal as to give rise to any increase of temperature. These precautions would amply suffice to prevent spontaneous ignition in stored coal on land; while special precautions, which will be found fully discussed in a paper read by me before the Society of Arts, would have to be taken in the case of coal for shipment.

The lecturer then passed on to consider a very common instance of spontaneous combustion, viz., the ignition of oily waste or greasy cotton rags. He stated that there were plenty of well-authenticated cases in which even a handful of waste which had been used for polishing furniture had ignited when thrown on one side, and had caused disastrous fires. He concluded by saying he had tried to bring forward the important fact that "spontaneous combustion" merely means that the heat due to chemical actions taking place in any substance—heat which has been unable to escape—has raised the temperature to the point of ignition. In speaking of spontaneous combustion, he thought it should be clearly remembered that it represented merely the acceleration of an action which had been going on slowly and surely, although the senses might have been too deadened to detect it; and if we wished to be hypercritical, "unaided ignition" or "natural ignition" would be a far more correct term to apply to it.

LAVAGE OF THE STOMACH IN CASES OF TOXIC POISONING.

EXPERIMENTS carried out by Hitzig, of Halle, have shown that after the subcutaneous injections of morphia in dogs, as well as in human beings, the drug very rapidly makes its appearance in the stomach (*The Medical Press*). For example, when the contents of the stomach have been removed by the stomach pump, within one or two minutes after an injection, traces of the drug have been found in the gastric contents, and the presence of the drug in that organ probably in this way accounts for the emetic effects so frequently observed in patients after such injections. The result of these experiments goes to show that about one half of the quantity of the drug injected may be removed by lavage. But if an hour or so be allowed to elapse before lavage is carried out, it has been found that the drug has been reabsorbed. Somewhat ingeniously the attempt has been made by Alt to ascertain whether the poison of venomous snakes could be got rid of by these means, and, so far, the experiments in this direction have been satisfactory in proving the utility of the method. Doses of snake poison injected subcutaneously into dogs were rapidly fatal to those animals in which nothing was done, but the same doses were recovered from when lavage of the stomach was carried out for about an hour after the injections. It would seem, therefore, that one of the first steps to take in case of snake poisoning is to freely wash out the patient's stomach. The difficulty, however, of this treatment would consist in having the stomach pump handy, and the opportunity of applying it early enough to secure the best effects from its use. To be of service, not more than a few moments, at the outside, should elapse before it is used—a practical impossibility in the majority of cases of snake poisoning, unless, indeed, the stomach pump came to be regularly included among the outfit of persons traveling in districts in which such contingencies are known to occur.

THE USE OF ORGANIC LIQUIDS EXTRACTED FROM GLANDS AND OTHER ORGANS.

DR. BROWN-SEQUARD concludes an interesting article on the above topic in the *British Medical Journal* for June 10, 1893. After speaking of the importance of liquid expressed from all parts of the economy, and of the importance of the injection of dog's blood in various affections, he finally concludes with an explanation of the mode of action of the various organic liquids.

When a morbid state, as myxœdema, or a series of symptoms such as we see in cases of deficiency of the internal secretion of any gland, exists, it is very easy to understand how the cure is obtained when glandular liquid extracts are used. We simply give to the blood the principle or principles missing in it. In 1856 the author, finding that certain internal secretions are essential to life, came to the conclusion, much later on, thus to supply them to the organism out of order from the lack of certain principles; and believing that the morbid phenomena of old age are due to the deficiency of a certain internal secretion, he resolved to try to give the missing elements of that secretion by means of injections of a liquid extracted from a healthy gland of the same kind as the one which age had rendered faulty. The great movement in therapeutics, as regards the organic liquid extracts, has its origin in the experiments he made on himself in 1889, experiments which were at first so completely misunderstood.

As regards other explanations of the mode of action of the various organic liquids which are employed, there is no room to say more than that which follows: 1. Certain principles entering the blood, after having been injected under the skin, give to certain tissues nutritive elements which our food digested in the stomach and duodenum could not furnish; it may be so for the cerebral or medullary liquids. 2. The tonic influence certainly existing when the liquids from the sexual glands, or some other liquids in a less degree, are injected, explains how nutrition is improved and how also morbid phenomena due to weakness may be made to disappear. 3. When the liquids extracted from the sexual glands are employed, as shown elsewhere, elements able to form new cells enter the organism, and thereby favorable organic changes can occur. 4. Organic liquid extracts resemble each other on account of the presence in the blood, and necessarily also in the various tissues, of elements coming from the internal secretion of all parts. It is not surprising, therefore, to find that any organ can give a liquid which might, in a measure, be used in place of any other. 5. When we know how great, how various, are the morbid, physical or dynamic alterations the nervous system can produce, it is easy to understand that what it can do in one way it can also do in just the opposite way, so as to re-establish the normal state physically and dynamically. This may serve to explain the extreme variety of favorable effects that may be due to certain liquids which increase considerably (as is proved) the power of action of the cerebro-spinal centers.

LÆLIA X NOVELTY.

THIS charming hybrid was raised from a cross between *Lælia elegans* and *L. pumila var. Dayana*, and

LÆLIA NOVELTY.

was produced by fertilizing a flower of the latter with pollen from the former. The plant was exhibited before a meeting of the Royal Horticultural Society on August 8, by Messrs. James Veitch & Sons, Chelsea, and the flower is faithfully depicted in the accompanying cut. The sepals and petals are pale purplish rose; the tube of the lip is white on the outside, and faint yellow within, the mouth of the lip is exquisitely waved and fimbriated, while the color is deep velvety purple. When shown, an award of merit was accorded it; the habit of the plant is very dwarf, it is pretty and distinct, but the effect of the seed parent is very marked throughout. *Lælia elegans* has been successfully used to produce hybrid forms, it was the pollen parent of the much talked about *L. dellensis*, and also of the lovely *Lælio-Cattleya Sedeni*. *L. pumila* and *L. p. Dayana* have had a good deal to do with the production of the *hybrid genus*, if so we might call it, of *Lælio-Cattleya*. Messrs. Veitch & Sons have raised a number of bigeneric hybrids with *L. pumila* or its variety as a seed parent.—*The Gardeners' Magazine.*

DRIFT SEED.

DR. A. LLOYD-JONES lately sent to Kew a seed of *Entada scandens* for determination. It is said to be exactly like one picked up in Swansea Bay, and supposed to have been conveyed thither by the Gulf Stream. In all probability this is the correct explanation of its presence there, but of course a large handsome seed such as this is often brought away from the tropics by travelers. Two hundred years ago Sloane recorded (*Philosophical Transactions of the Royal Society of London*, 1696, xix., p. 298) the fact that this seed and three other West Indian seeds were commonly cast ashore in the Orkneys. And Linnæus (*Amœnitates Academicæ*, viii., p. 3) mentions this among other seeds thrown up on the Norwegian coast. Some few years ago, too, several plants of *Entada scandens* were raised at Kew from seeds cast up in the Azores. There is little doubt that in all these instances the seeds had drifted from tropical America obliquely across the Atlantic. But the most interesting point is that after floating for weeks, and may be months, in sea water they retain their germinating power.

"BOYS TO MEND."*

EVERY one who has spent some time in the southern portion of Manchester, England, has encountered in the main streets a little army, the nature of which at first perplexed him. It consists of some four hundred boys, clad in blue serge, with Scotch caps, military in their carriage, sound and stalwart of limb, looking healthy and strong, and preceded by a really first rate band. Walking by their side at a little distance, one in front and one behind, are two somber figures, members of the Christian Brothers, and the little regiment which they are conducting, or rather accompanying, through the streets of the city consists of the boys of the Industrial School in Plymouth Grove. These youngsters, with very few exceptions, come from what we may call the criminal or vagrant class. They have all been convicted for some offense, or found by the police without any suitable guardianship. Their offenses vary from the terrible crime of sleeping on a doorstep, or stopping away from school, or begging from a passer-by, or having no fixed residence, to the more serious misdemeanors of stealing from the market, or even in some cases of a daring robbery from a private house or shop. Most of them, or at least very many of them, had absolutely worthless parents, drunken, cruel, neglectful, and their homes, if homes they could be called, were schools of vice rather than of virtue. So unsatisfactory are their homes, that it is a very rare occurrence for a boy to be allowed to pay a visit to his friends, and only when their respectability is thoroughly established. The Brothers have learned by sad experience the danger of allowing the children committed to their care to spend a day or two with their fond parents.

The boys remain at the school until they arrive at the age of sixteen, and one great object aimed at by the Brothers is to render them fond of it by making life pleasant to them while they are there, by rendering it a real home to them. To this must be added such a preparation for after life as shall enable them to be certain of earning good wages and holding a respectable position in the world. To this end every boy is taught some useful trade or handicraft, and as soon as their school time is over they are drafted off to one or other of the workshops, remaining there and working for themselves until they arrive at the age of sixteen. Then comes the time of trial! Yet the official returns recording their after career vouch for no less than eighty-seven per cent.† known to be going on well, at least during the three years over which the record extends.

In the system of the school as it exists at present the most wonderful feature is the self-government of the boys. Over each section of twenty-four there are two non-commissioned officers or monitors. The sergeant of the section at every duty is responsible for the conduct of the rest. He is obeyed with a promptitude and a willing obedience that seem incredible to one who has not grasped the central idea of willing obedience that rules the whole establishment. The other governing principle of the school, and one that insures a good spirit throughout, is to make the boys themselves the judges of ill-doing, and to develop in them such a healthy public spirit that they shall be the first to drag any offender to justice. If a boy is disobedient, idle, or impertinent, the rest of his company make his life a somewhat uncomfortable one, and sometimes the Brothers have themselves to interfere to protect from summary and rather severe chastisement some offender who has excited the indignation of his comrades. This lofty sense of right is the result of the unfailing kindness and consideration and personal interest shown in them by the Brothers, which appeals to the gratitude of their young hearts, and which is to many of them a new and delightful experience in life. There is also another motive for good conduct. Each section of twenty-four that is generally satisfactory receives, from time to time, some little indulgence. If the ill-behavior of an individual robs the section of such enjoyments, the wrath of his fellows often takes a practical and painful form, which is more effective and generally more severe than the penalties inflicted by authority.

Not that all punishments can be left to the boys themselves. For minor offenses extra drill or the penance walk (to pace alone in the playground during recreation time) are common penalties, for graver misdemeanors the cane or the birch. The latter punishment is inflicted only by the Brother Superior. The culprit is tried in solemn form; the witnesses to his ill-deed are summoned; he is given full opportunity of self-defense, and only receives the punishment when he has acknowleged his fault, and has been asked what amount he considers that he deserves. As a rule he will allot to himself a heavier sentence than his merciful judge has decided to inflict. The schools are, needless to say, under government, and some of the Brothers are certificated. All the teaching is done by the Brothers themselves, assisted by some of the bigger boys as pupil teachers. Ordinary government regulations prevail.

I have indicated the distinctive excellences of the system pursued by the Brothers, but it may be worth while to restate them.

1. The system is essentially a home system, and the tone of the whole house is domestic rather than disciplinary. The law of love prevails.

2. The boys are trained to govern themselves, and the Brothers interfere as little as possible in the ordinary discipline of the house.

3. The employments of the boys are not for employment's sake, or merely to fill up time, or with a view to making money for the school, but all are directed to the promotion of the future success in life of those engaged in them. In this respect, as in all

* R. F. Clarke, in the *Month*.

† Out of 255 discharged in three years, 1887–90, 219 were doing well, 9 dead, 17 unknown, 7 doubtful, 3 convicted of crime.

else, the boys cannot help seeing that everything in the institution is simply directed to their good.

4. In compliance with the same general principle, the great liberality with which the boys are treated is very remarkable. As far as is possible in such an institution, they have the best of everything, the best of food, the best teaching, the best lodging, the best provision for their future. They are thoroughly well treated, and show their appreciation of it by their excellent conduct and their healthy appearance, their willing industry and their appreciative gratitude in after life.

SUBTERRANEAN REFUGES OF GAUL.

SUBTERRANEAN refuges are very numerous in those parts of France where the subsoil is formed of a rock both soft and consistent, as in Beauce, Champagne and Artois. In 1879, during the reconstruction of the church of Maves (Loir-et-Cher) some very sinuous tunnels at 12 or 15 feet beneath the surface, that were almost uniformly 4·4 feet in height by 2·6 in width, and which, after passing under the houses of the village, ran by quite a long ascent to open in the neighboring fields, where their orifice, closed under the arable soil by a wide stone, had been long unknown to the present population, although a tradition of the existence thereof had been preserved. It was through these inclines that the domestic animals were introduced. A few men remained outside, carefully hid the

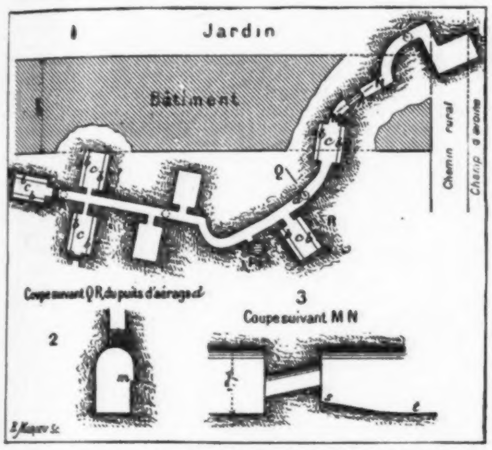


FIG. 2.—PLAN OF THE TUNNEL ON THE BRETIGNY FARM.

entrance by means of stones or brushwood, and then entered the tunnels themselves through wells that will be spoken of further along.

Roman money, principally of the time of Nero, has been found therein. It was a question, then, here of one of those subterranean retreats spoken of by Caesar, Tacitus, Pliny, Florus and Balderic. Gallic and Gallo-Roman vases and arms, moreover, have been found in the tunnels of Artois, of which we shall speak further along.

In 1860, at Balatre, a hamlet of the commune of Suevres (Loir-et-Cher), the earth caved in under a cart load of sheaves of wheat, and the funnel thus formed permitted of entering long and tortuous tunnels that were explored by the learned curate of the parish, Abbot Morin, and in which were found three different exits debouching at the surface at great distances through very steep ascents.

The center of the system forms a sort of cross roads, whence start four corridors 5 feet in width leading to fourteen square, circular or semicircular, more or less spacious, halls connected with each other by narrow zigzag passages. One of these latter debouches in the wall of the deep well of Balatre. One came here to draw water, breathe and keep watch, for very near by we find a small chamber with a bench cut in the tufa, as is the rest of the gallery, and serving as a seat.

In addition to the well, three vertical conduits filled with large stones properly arranged allowed a little light and air to penetrate. Further along, apropos of the tunnels of Bretigny, we shall see how these air holes are organized. In one of those of Balatre a thick stratum of soot which still blackens the walls bears witness to long sojourns in these dark dwellings.

These galleries, excavated in a soft tufa of a very fine grain and of a bright yellow color, have been so perfectly preserved that we still see upon the facing of the vaults and walls the imprint of the tools that served to construct them and the smoky traces of the torches that afforded the inhabitants light.

What seems especially curious to us, says Abbot Morin, is in each gallery a system of defense that merits study.

At the three exits, at the very base of the ascents, covered with a long row of flat stones, wide grooves are formed in the tufa for the reception of planks forming a barricade. Here and there in the walls and partitions of tufa we remark holes in the form of the mouth of a furnace at 4½ feet above the floor, adapted for guarding the avenues with eye and ear and for pinning an enemy against the opposite wall by means of a spear or other weapon when he was preparing to pass from one gallery to another making a bend therewith. Moreover, it was possible to pass from one gallery to another only through a narrow aperture on a level with the floor of these tunnels. The enemy had to crawl in order to proceed further, but when his head appeared beyond the horizontal passage, the Gaul or troglodyte, concealed on one side, crushed his head or cut his throat (Fig. 1).

A dozen years ago, I myself explored a tunnel that had just been discovered near Chartres on the Bretigny farm, where in 1360 was signed the famous treaty bearing this name. I made a sketch of the part that I traversed. Access is had to it by an air shaft, A (Fig. 2, No. 1), the contents of which have fallen in and thus revealed the presence of an excavation. No. 2 of the same figure shows a section of another of these shafts, *d*, that has remained intact. It will be seen that it is filled with stones designed to conceal its presence, and that the stability of these stones had to be assured by stays that rested at *m* upon a ressault of the wall of the gallery. These galleries, excavated in a semicircle at the upper part, are 3¼ feet in width and 5¾ in maximum height.

Chambers of the same height, 6½ feet in length and 5 feet wide, are distributed to the right and left of the gallery. The majority are provided with benches cut in the walls. At P (Fig. 2, No. 1), we find a well 10 feet in depth where the level of the water is found at a short distance beneath the floor of the gallery. At *r* the gallery terminates abruptly, but in the end wall, at 16 inches above the floor, there opens a circular conduit about 24 inches in diameter slightly sloping upward. When we enter this in crawling, we again find, at a distance of 5 feet further, the gallery with its ordinary dimensions, which I was enabled to recognize for a short distance only on account of a downfall of earth that barred my passage at E. It was evidently on this side that the gallery was entered, for it terminates at H in a chamber. The role played by the conduit, *r*, for the defense may therefore easily be seen.

The inhabitant of the tunnel, pursued by invaders, taking refuge toward the end of his retreat, in running, ascended the small inclined plane, *s t* (Fig. 2, No. 3), and precipitated himself, arms extended, into the central conduit, in order to reach the other side, where he was sure of finding friends only. His enemy, on the contrary, could not enter this narrow conduit without a very legitimate apprehension, and here, as at Balatre, when his head appeared at the other end, it was exposed without defense to all the blows of him who was waiting there.

Mr. Terninck, who has visited the tunnels of Artois, describes them as follows:

They are long and narrow passages excavated either in the clay or marl, roughly worked and exhibiting no trace of masonry. In these galleries small chambers open here and there. Some of these have served as a shelter for domestic animals of all kinds, and there may be seen therein the location of the racks and the friction of the animals against the walls. The others sheltered the women, old men, children, men who were not to fight, and the riches it was desired to keep from the enemy. Here are the smoky traces of the lights that illuminated these deep redoubts, and likewise kitchen debris. Finally, here and there are wells very often extending nearly to water and designed to furnish the recluses with air and drink. Some of these refuges are very extensive. That of Harmies has eight passages and three hundred cells, that of Arleux has five galleries, and that of Morchies has three superposed stories.

It will be seen that, at a certain epoch of our history and in certain regions, these tunnels have constituted a true system of fortification. The population in the vicinity of the mountains has taken refuge therein at all times. They easily defended themselves therein, thanks to the obstacles offered by the configuration of the soil. So in the primitive tongues it is the same root that has served to form the words *bal*, *bar*, *barri*, *berg*, *burg*, all of which signify mountain or fortified place.

In the great plains too distant from these natural refuges, it was necessary to create factitious ones, especially at the epochs in which the great migrations starting from the east followed each other, so to speak, periodically.

Upon the steep banks of rivers, the rock, presenting itself by its face, so naturally invites man to excavate a shelter therein when it is soft, that this mode of habitation is still used on the banks of the Cher, Loire and Loiret. It is precisely in these regions that we find the most numerous and finest specimens of a species of subterranean galleries as yet too little known, and that await their Martel.—*A. De Rochas, in La Nature.*

FIG. 1.—SUBTERRANEAN GALLERY OF BRETIGNY, NEAR CHARTRES.

THE NECROPOLIS OF ANCON, PERU.*

By GEORGE A. DORSEY, Superintendent of Section of Archæology, Department of Ethnology, World's Columbian Exposition.

WHAT Ohio is to the archæologist of the northern half of the American continent Peru is to the southern, and the advantage is with the student of Peru. Not only did the Peruvian attain to a higher and more complete civilization than his northern neighbor, but natural conditions have assisted most materially to preserve for us a complete story of his daily life. On the coast of Peru it never rains, and his extensive temples and houses are outliving his descendants. In the interior he built temples and fortresses of stone which will outlast the Quichua tongue.

Of the innumerable seats of former power and population on the coast, none, perhaps, is better known than that centering in or near the valley of the Rimac, famous alike for its Temple of the Sun, at Pachacamac, and the extensive Necropolis at Ancon. There is scarcely a museum in the world which does not contain photographs of the one and objects of some kind from the other. There is scarcely a month in the year when there is not a man-of-war anchored in the harbor of Ancon for the purpose of making explorations. Nor is there hardly a day in the year when the rod and the shovel of the hauciero (or one who works in the graves) is idle—working among the graves for his own gain or in the employ of some student or curious visitor from Lima.

When this great burying ground was begun and who the people were who made it, are questions that will probably never be satisfactorily answered. The time since it was first used must have been centuries ago, as shown by its vast extent (covering about ten thousand acres) and the evidences the graves themselves produce. Bodies placed side by side, only a few feet apart and evidently buried under the same circumstances, show great difference in time as to their interment.

My first introduction to Ancon was on the evening of June 6, 1891. About five miles from the coast the train rapidly descends around a mountain and enters the plain. Here the best view is obtained, and we could see the desert glistening in the sun. Back of us and shutting in the plain on three sides were giant hills, the outskirts of the lofty Andes beyond. In front of us lay the Pacific, forming the fourth boundary of the plain. As we neared the coast the surface became more undulating and like the waves of a Western prairie.

The little town of Ancon is in summer a gay watering place for the wealthy of Lima, but in winter it is forsaken and dreary, inhabited by a few fishermen only. One hotel is kept open all year, and there I found most comfortable quarters during my stay. Early the next morning I started off with five men armed with shovels, steel rods and baskets.

The men were all experienced, two of them having worked with Reiss and Stubel, and knew better than I how to proceed. A walk of about a mile brought us up in the center of the burying ground. Around us in every direction lay the contents of graves opened in former times. The surface was literally strewn with bones—here a skull, there an arm bone, here a pelvis, fragments of pottery, yards and yards of cloth, pieces of rafters, broken reeds, partly decayed rush mats, and bones, bones, bones, in every direction, bleaching and whitening in the sun.

Within an hour we had the first grave opened and the note book reads: Grave No. 1; Mummy No. 1. Grave seven feet deep, bundle well made but very old and much decayed, found on south side of the grave; got skeleton, five pots and a loom.

And so one day faded into the next until seven weeks had rolled by, and one hundred and twenty-seven graves had been opened, and from them one hundred and eighty-six bodies had been taken.

The graves do not occur at regular intervals nor is there anything on the surface to mark their presence. The method of location however is very simple. The surface of the whole plain to a depth of two feet is of pure sand. Beneath this is a bed of rough gravel, very hard and compact. This gravel cannot be penetrated easily, unless it has been disturbed at some previous time. So the hauciero repeatedly thrusts a steel rod into the loose sand until he is able to locate one of these disturbed portions. Then the rod can easily be thrust downward its entire length, and the probabilities are that a grave has been located.

One of the greatest problems that presented itself was the removal of the bundles from the graves to the hotel and the subsequent packing. I finally decided upon this method: After the grave was thoroughly cleaned and the contents noted in the record book, the grave was enlarged, often to twice its original size, then on the floor of the grave we spread a piece of burlap of double width. On this was strewn a bedding of straw, the bundle was then carefully lifted and deposited on the burlap, more straw was placed over and around the body and it was then sewn up completely like a sack of wool. This was then carefully lifted out of the grave and placed on a stretcher to be carried to the hotel to be packed with more straw in boxes.

The depth of the grave varied probably with the rank of the person. Bodies of children were generally found near the surface, but sometimes at great depths. The grave nearest the surface was in the sand not over

* Read at the meeting of the American Association for the Advancement of Science, Madison, 1893.

one and a half feet deep; the lowest that I examined was in the gravel twenty-two feet. Many of the bundles found either fell apart or have since been unwrapped, and so it has been possible to determine the sex of the person inclosed. From the observations thus made, I have found the graves of twenty-two males to average little less than six feet deep, while twenty-five graves containing females average a little less than six feet. Additional data might of course change these figures.

The grave is generally circular and about four feet in diameter. A few graves have been found, however, square or nearly so. These graves invariably had the appearance of being very old.

About twenty-five per cent. of the graves were covered with a roof. These generally consist of four or five rough sticks of algaroba, which served as rafters and were placed parallel over the graves at a depth of one to two feet. Over these and resting on them was a mat of reeds bound together by rope. Often there were two mats, one placed transversely over the other. The more elaborate roofs were covered with a thin, compact layer of clay or of bromeliacious plants, or of both. These roofs were sometimes in such a good state of preservation that they had withstood the weight of the sand above and had not caved in; consequently there was found a hollow, undisturbed chamber beneath. The roofs were always larger than the graves, and were square, averaging about six and a half feet. Besides the roofs proper, the bundles were often immediately covered with a well-made mat of rushes. Of forty-six graves, not one male was covered with a roof or mat, while eight females had well made roofs and nine more were covered with a matting of rushes.

After the roof had been removed and the grave cleared of the sand which had fallen in, the bundle was found at the south side of the grave, and arranged around it were the vessels of food, work baskets or whatever the occupant owned in life. From these objects we are able to reconstruct much of a past civilization.

On examining the bundles, we find that no two were prepared for burial exactly alike. Generally the bodies were placed in a sitting posture, with the knees drawn against the breast and the hands folded over the face. Frequently the bodies so doubled up were buried lying on their backs. This was almost invariably the practice in the case of children. Only three bodies were found buried at full length.

It is interesting to note that all three were buried with the face downward and that they were poorly wrapped. Spindles were found with two of them. One body was found in a very peculiar position, in a half sitting and a half reclining posture, with the feet bent back under the body. The wrappings were very scant and nothing else was found in the grave.

Looking now more especially at the wrappings of the body, we find infinite variety, from the child wrapped in a single piece of cloth to bundles swelled to enormous size by the numerous garments and coverings of plants. A typical well-wrapped body would reveal the following coverings: A false head, bright colored poncho, finely woven mat of rushes, large pieces of cloth, and a two-inch layer of plants and leaves, several thicknesses of cloth and a layer of raw cotton still containing the seeds are found over the face and breast. The plants just mentioned apparently played a very important part in the preparation of the body for burial. They were used not only for enveloping the body, but for building up the shoulders even with the top of the head, so that it is not always possible to detect the location of the head from any outward indication. Thirty-seven per cent. of the graves contained bodies which were wrapped in plants, while over ten per cent. were provided with small bags or sacks of plants, which were either sewn fast to the bundle or suspended from the false head.

The object of the false head or maskoid is a matter of conjecture. They have not been studied sufficiently as yet nor has enough attention been paid to their resemblance to the maskoids of the north. In forty-six graves seven bodies were so decorated, and five of these were women. They all differ in shape nor are any two quite alike in construction.

In general it may be said that they are about four inches wide and six inches long, and are simply constructed of cloth and straw and resemble a small cushion. The eyes are of shell, the nose of wood, and the mouth of yarn. Those found on women were further decorated with ear ornaments made of tiny reeds arranged in the shape of a star, and held in position with ribbon-like bands of the outer covering of large reeds or leaves of corn. The face is often painted red or yellow.

Over the top of the maskoid found with the men was often placed a woven band of straw and at the back was a feather plume. These plumes were carefully made, each quill of the feather being bound separately with thread and the whole then made fast to a piece of wood. When the maskoid is further provided with false hair the effect is very striking.

Many of the more delicate objects were found inside the wrappings, and include spindles, beautifully decorated gourds, pots, fine nets, bags, straw bands, knitted caps, garments, slings, etc. Inside of the wrappings and around the neck of the women were often necklaces of shell or colored beads. The art of tattooing was well known and was practiced on both sexes. The hands, arms, and breast were covered with small triangular-shaped figures in parallel rows. In one case, that of a man, the whole breast was tattooed with an intricate design which cannot now be clearly distinguished.

The objects found in the grave around the bundle vary considerably. The most common objects are calabashes and earthenware vessels containing food, or were found covered, and probably contained a beverage of some sort. The pottery is not remarkable either for its shape or for its decoration. The most common form is that of the plain, unadorned round-bottom cooking pot, with the outside still covered with soot. The decoration when present is generally in the form of small relief figures or simple geometric designs in black and white.

The foods found include ears of corn and parched corn and meal, peanuts, dried fish, sea crabs, guinea pigs, yucca, pecay, and some other fruits the names of which I have not been able to ascertain. The leaves of the coca are found in almost every grave and with both sexes.

The remaining objects from the grave I shall mention as they occur with the man or woman. With the man only are found agricultural implements, war clubs, canes, slings, tweezers of copper and silver, flags, fish nets, pottery-making implements, straw bands and tablets. The agricultural implements are not numerous, and are only sharp-pointed, wedge-shaped sticks. The war clubs consist of a heavy five-pointed, star-shaped head of stone mounted on a stick of wood an inch in diameter and four feet long. In one case the head of the stick was decorated with a bunch of coarse hair. The canes resemble the rough walking sticks of to-day, but are always over four feet long. Slings are still used to a great extent in the interior for driving llamas or killing birds or game. Those found in the graves do not differ materially from the modern ones. They are generally made of llama's wool, braided and often beautifully colored and decorated with tassels.

None of the bodies found had any trace of hair on the face. This fact explains the use of the tweezers so often found wrapped up in the bundles. They are generally of copper and are cylindrical in shape. In two of the graves a flag or banner was found. They are both alike and are twelve inches wide and sixteen long. The ground color is crimson, with a symbol like a Greek sigma worked in black and orange. Both were mounted on poles about five feet long, and they were placed at the right of the bundle. Probably the objects least understood and of the greatest significance from the graves are the tablets found leaning against the bundle. They are made of a piece of white cotton cloth stretched over a framework of reeds from six to ten inches square, fastened at the back and bound to a round stick of wood painted in black and red bands. The stick is about two feet long, and is thrust into the sand near the bundle. The face of the tablet is painted in black and red figures, generally rude and of a conventionalized human form. It is a curious fact that always an even number of tablets are found in the same grave, never less than two or more than six.

Fish formed an important article of food at Ancon then, as it does now, and they were caught in about the same manner—in nets and seines. Over thirty per cent. of the men found in the graves were provided with nets. Only one fish hook and line was found, a rather singular fact, as various forms of the hook and line are found below Ancon on the coast. The line mentioned is small and perfectly made, the hook is of copper, very small, semicircular in shape and sharp at both ends, and is not provided with a barb of any sort. In the same grave were found several incompleted straw bands, together with several bunches of the splints, which the owner was probably using at death. The male occupant of another grave was accompanied by a well-preserved yellow dog. The remains of llamas and parrots are often encountered.

As the male bundle has its peculiar decoration, the tablet, so that of the female was decorated peculiarly also. On the outside of the bundle and leaning against it were frequently numbers of small reeds, two feet long, and bound into bundles of three each, by colored yarns so placed as to form successive bands, or arranged in spiral figures one overlapping the other. These wand-like reeds have no use that I know of and were probably symbolical in their nature.

A more interesting article of the grave of the woman is the work basket, with its contents, which furnish us many valuable data. Two kinds of baskets are found, one made of reeds two feet long, ten inches deep and ten wide. The other is woven of straw and is about half the size of the one made of reeds. In the baskets are found spindles, hand looms, cotton, wools, yarn, ear ornaments, tubes of paint, leaves of coca, fruit, etc.

The spindles are of different kinds. The most common form is made up of a reed four inches long and less than one half inch in diameter, which forms the whorl. Into each end of this is thrust a round piece of hard wood, sharp at both ends. This form of spindle is rarely decorated. In the other form the whorl is of terra cotta, copper, or a short reed mounted on a perfectly rounded wooden shaft. In one grave I found a bundle of seventy spindles of this latter kind, and all beautifully decorated and exquisitely made. Many spindles contain a half-finished spool of yarn, which is still attached to the bunch of wool or cotton. The wools include llama, alpaca, and vicuna. The dyeing was done before spinning. The looms are very simple, consisting of three round and three flat sticks, but with those the most delicate work was accomplished. Some of the fabrics are remarkable both for texture and design. Small garments woven in the same manner as Gobelin tapestry are not uncommon, while they also embroidered and did drawn work most skillfully and tastefully.

In fact the degree of perfection and skill to which these people attained in textiles is wonderful, and has always been the glory of ancient Peru. The other objects found in the graves of the women do not differ from those found in the graves of the men, and of those I have already spoken. The tubes of paint mentioned as found in the work baskets are interesting, for they contained the paint which the lady of Ancon used on her face. We find the two colors white and red, but she applied them differently from the manner in which they are used in these degenerate days. She put the white on her cheeks and the red on her forehead. She also wore ear ornaments already described and silver bands on her wrists.

The contents of the children's graves consist of such objects as we might expect to find, small pots of food and little clay images, and in a few cases wooden tops. One fact alone is worthy of attention—several children have been found wrapped in the skin of a dog or of a llama, a covering which is never found with the adult.

I have spoken of the desert of Ancon and said it never rains on the coast of Peru and that the nearest ruins are nine miles distant. Where then did these people come from and how did they live? These questions have often been asked and never yet, I believe, satisfactorily answered.

In many places at Ancon I have found kitchen refuse at a depth of four feet—bones, rags, corn, shells, potsherds, reeds, and canes promiscuously mixed. This to me is sufficient to prove that the plain has been inhabited for a great period of time.

Further, I believe, they buried their dead under their houses or near them, and that their houses were built of canes plastered over with mud, just as the cathedral of Lima is built and all the houses on the coast of Peru—light and flexible, so as to withstand the earthquake shocks. Further I have traced the ruins of an ancient azequia or an irrigating canal round through the hills to the river Chillon, distant twelve miles, and I believe the present barren waste of Ancon was once a great fertile field dotted with patches of corn and beans, alive with an industrious people.

Even within modern times great azequias have been destroyed in civil revolutions, and now exists a great dry sandy plain where a few years ago was a sugar hacienda. Peru, with all her unbounded resources, does not advance as she ought. On the contrary, each year marks the destruction of a reservoir, an azequia, or a road of a people we know must have been in many respects highly civilized and enlightened now in a state of utter degradation and decay.

ENGINEERING PROBLEMS IN THE CONSTRUCTION OF LARGE REFRACTING TELESCOPES.*

By Worcester R. Warner.

The continued and growing demand of astronomers for larger and more far-reaching telescopes has presented an entirely new series of problems, for the solution of which the best talents of the engineer are brought into play.

Size and penetrating power, while most important, are not the only requisites of the great telescopes of today; for they must be specially designed and arranged for spectroscopic and photographic as well as for micrometric and visual work. This combination of uses greatly increases the complexity of the problems and the difficulty of their solution. The suggestion has been made periodically for the last fifty years that the proper system of construction for large telescopes is to place the optical axis of the instrument in a horizontal and permanent position on the ground, pointing due south, and to reflect the images of the heavenly bodies into it by means of mirrors. This would at first sight seem a happy solution of the engineering problems, were it not for the fact that in large instruments it introduces optical difficulties well-nigh insurmountable; for the mirrors must be much larger than the objectives into which they reflect the light, and to give good results their surfaces must be optically perfect, and must be mounted so as to be free from deflection in all positions. These conditions are so difficult to obtain that, for large telescopes, this system is practically ruled out, while for small or medium sized instruments the ordinary construction with a movable tube is much more convenient.

Prof. Langley has, however, recently erected at the Smithsonian Institution a 12 in. horizontal refracting telescope, having an 18 in. plane mirror, which is said to be very perfect and successful in its operation. It is the form known as the siderostat.

Again, much study has been given to a form of telescope known as the equatorial coudé, in which the optical axis of the telescope is parallel to the axis of the earth, and the light of the star is reflected into it by two mirrors. This is very convenient for the astronomer, who can sit in his chair and observe the stars as easily as he can use his microscope; but the loss of light and definition by the double reflection, as well as the deflection of the mirrors, and the varying temperatures to which the different parts of the instrument are subjected, render this construction far from perfect; so the problems incident to mounting the largest telescopes with movable tubes still confront us.

The three largest telescopes in this country, viz., the new 26 in. equatorial of the Naval Observatory at Washington, the 36 in. Lick telescope at Mt. Hamilton and the 40 in. Yerkes telescope, just completed for the University of Chicago, and now erected in the Manufactures and Liberal Arts building at the World's Columbian Exposition, may serve to illustrate some of the modern methods of solving these problems and form the subject of this paper. As the last mentioned and largest is the most available for examination, we will confine the discussion to it.

In designing a large telescope, the first element to which the engineer naturally gives his attention is the tube; for, while its office is a very simple one, being merely to hold the objective and the eyepiece in their proper relation to each other and to enable the astronomer to direct the optical axis to the star, it is an extremely important factor.

The two most essential points in the tube are lightness and rigidity, the former for ease of motion and the latter to reduce flexure to a minimum. The material best calculated to give these two qualities seems at the present time to be sheet steel. Some material having aluminum as a base has been sought for, but thus far none has been found giving the requisite rigidity.

The form of the tube has much to do with its rigidity, a slight increase in diameter at the center serving to stiffen it to a great degree, and causing thinner material to suffice. No form of internal bracing seems so effective as the same amount of material used in the shell itself. In the tubes of the three large telescopes named there is, therefore, no bracing whatever, all the strains, both in tension and compression, being taken by the sheet steel forming the tube.

The tube for the 40 in. Yerkes telescope is 42 in. in diameter at the objective end, 52 in. at the center, and 38 in. at the eye end. The sheet steel forming the tube varies from 7/32 in. in thickness at the center to 1/8 in. at the ends. The total weight of the tube is 6 tons.

The declination axis carrying the tube is of forged steel, 12 in. in diameter and 12 ft. long, its weight being 1½ tons. This runs in segmental babbitt bearings in the declination sleeve, which weighs 4 tons. The polar axis carrying the whole system is of hard forged steel, 15 in. in diameter at the upper bearing and 12 in. at the lower bearing, and weighs 3½ tons.

Just above its upper bearing it carries the main driving gear, weighing one ton and having 330 teeth, by which the movement of the driving clock is communicated to the polar axis.

The great weight of the bearings of these axes is al-

* Read at the Congress of Astronomy and Astro-Physics, Chicago, 1893.

most wholly relieved, and the resistance changed from sliding to rolling friction by means of three bracelets or live rings of steel rolls. One of these encircles the declination axis near the tube and one is placed above each bearing on the polar axis. These anti-friction live rings run in steel yokes, and are pressed against the axes by means of adjustable spring levers.

The live ring of rolls which is on the declination axis near the tube is the center of gravity of the system comprising the tube and the declination axis with their attachments, this one series of rolls serving to take the weight off both bearings of the declination axis, and so nearly eliminating friction that less than one pound of direct pressure on the tube is required for each ton of weight moved. This live ring is composed of 16 in. rolls, 5 in. long and 3 in. in diameter, and carries a total weight of 8 tons.

The live ring at the upper end of the polar axis is composed of 16 rolls, 6 in. long and 4 in. in diameter. This sustains a weight of nearly 20 tons. The end-thrust of all this great weight, due to the angle at which the axis is placed, is taken on a double series of 40 one in. hardened steel balls.

The methods of balancing the movable parts of the Yerkes telescope have been a special study, with results which seem all that can be desired.

The heaviest accessory to be used with the telescope is the solar spectroscope. With this in position, the tube is accurately balanced. Weights are then placed on the extension of the declination sleeve until the whole system is in balance. When the solar spectroscope is to be removed, sufficient supplementary weights are placed at the side of the eye end of the tube, so the balance is not disturbed.

The equatorial head and its bearings supporting the polar axis and the entire movable part of the telescope is cast in one piece, its base conforming to the rectangular shape of the column.

The column is 11 ft. × 5 ft. at the base, tapering to 10 ft. × 5 ft. at the head. It is cast in five sections, having internal flanges for securely bolting it together. In the upper section is placed the driving clock. A spiral staircase at the south side of the column gives easy access to the driving clock, and also to the balcony surrounding the head.

The driving clock is governed by a double conical pendulum, mounted isochronously, and making 60 revolutions per minute.

A driving weight, considerably in excess of the amount required to drive the telescope, is used with this clock, the surplus of power being taken by a friction ring placed just above the pendulum. The arms of the pendulum are so arranged that in operation they always take their natural and theoretical positions, not being swerved therefrom by the action of the power on the friction ring above mentioned. When the clock is unclamped from the polar axis, all the power required to move the telescope is instantly transferred to the friction ring, and the pendulum maintains its theoretical position and normal rate. An electric motor is provided for automatically winding the clock.

All clamps and slow motions, both in declination and right ascension, are operated by handles at the eye end within easy reach of the observer, while the assistant on the balcony can also set the telescope in any position and read the circles. In addition, electric motors are provided for operating all quick and slow motions and clamps.

These various motions and clamps being operated by the astronomer at the eye end of the tube either by hand or by means of the electric motors, and also by the assistant on the balcony, are so arranged that any one method of working them is not interfered with by either of the others. Each motion is therefore always ready for action and no conflict is possible.

Incident to the construction of large telescopes, problems are presented in providing domes to cover them, and elevating floors by means of which their use is made more convenient.

These problems have been very satisfactorily solved, for the domes of the best construction will revolve by a direct power of two pounds per ton of weight moved. Elevating floors of nearly the diameter of the domes are in successful use with the 36 in. Lick telescope and also with the 26 in. telescope at the new Naval Observatory at Washington. Both these elevating floors are operated by hydraulic power, the simple movement of a lever sufficing to raise or lower them.

Such is the solution of some of the problems incident to the construction of large telescopes and their equipment to-day. What improvements the morrow may bring forth it were hazardous to predict.

THE CONSTITUTION OF THE STARS.*

By EDWARD C. PICKERING.

OUR only knowledge of the constitution of the stars is derived from a study of their spectra. This has been done at the Harvard College Observatory as a portion of the work of the Henry Draper Memorial. Photographs have been taken of the spectra of the brighter stars on a large scale, some of them being as much as six inches in length. To photograph the fainter stars, a smaller dispersion is employed, and in this way the spectra of stars as faint as the ninth or even the tenth magnitude may be obtained. To study the stars too far south to be visible in Cambridge, expeditions have been sent to South America, and a permanent observing station has been established near Arequipa, Peru, at an altitude of about eight thousand feet. There the southern stars are photographed with instruments similar to those used in Cambridge for the northern stars. A few spectra have been photographed with plates stained with erythrosin, which renders them sensitive to the yellow rays. A portion of the visual spectrum not shown on an ordinary plate is thus photographed. Images of the sodium line "D," in which the two components are clearly visible, have been obtained for several stars. In all, many thousand photographs have been collected, including stars in all parts of the sky, from the north to the south pole. The spectra of all the bright stars have been photographed as described above, with a large dispersion, and the spectra of a large portion of the faint stars with a small dispersion. A careful study has been made by Mrs. M. Fleming of the fainter stars, and of the brighter stars by Miss A. C. Maury. From this it appears that while at first sight many spectra seem to be unlike, nearly all of them can be arranged according to a simple system. It is not proposed in the present paper to consider the cause of these differences. For purposes of description, it will be convenient to treat them as if due to differences in composition only, although there is evidence that the actual variation is rather in the order of growth. The spectra of ninety-nine one-hundredths of the stars could be imitated by combining in different proportions four sets of lines. These are first hydrogen; secondly, a substance presumably calcium in such a condition that it gives the broad lines "H" and "K," which are the most marked features in photographs of the solar spectrum; thirdly, the substance, or substances, which give the lines characteristic of many of the bright stars in Orion; fourthly, the lines of the solar spectrum omitting those due to hydrogen and calcium. These four classes of lines may be described as hydrogen, calcium, Orion, and solar lines. We may now arrange nearly all the visible stars in a sequence such that the spectra change insensibly from each one to the next. At one end of this sequence are such stars as α Virginis, α Eridani, and β Canis Majoris. In them, the Orion lines and hydrogen lines are well marked. The principal Orion lines have wave lengths 382, 402, and 453, and are sometimes nearly as intense as the hydrogen lines. These spectra are designated by the letter B in the provisional classification adopted in the Draper catalogue. In the next stars of the sequence the Orion lines have become fainter and the hydrogen lines stronger, while the calcium and solar lines are faintly seen. This gives the large class of stars called A in the Draper catalogue, of which the Milky Way is mainly formed. The stars α Canis Majoris and α Lyræ are examples of this class. The hydrogen lines here so greatly exceed all the others in intensity that in faint spectra they are the only lines visible. The line "H," due to hydrogen, has a slightly greater wave length than the corresponding line due to calcium. When these lines are well defined and about equally intense the H line appears double. This is well shown in such stars as α Cygni, in which the hydrogen lines are narrow, but is also distinctly seen in good spectra of α Lyræ and other normal first type stars. In some stars, such as α Aquilæ, the hydrogen and other lines are broad and ill defined, as if the spectra were out of focus. It is possible that this is due to a rapid revolution of the stars around their axes, by which the portion near one edge would be receding while that near the opposite edge is approaching. But the velocity required, about a hundred miles a second in the case of α Aquilæ, is so great that such a hypothesis must be accepted with caution. The calcium and solar lines now gradually increase, and the Orion lines diminish in intensity, until they disappear; the hydrogen lines, "G" and "h," also diminish. This class of spectrum is called F in the Draper catalogue. The K line is as intense as the H line and the h and G lines are distinctly fainter. The stars α Argus (Canopus) and β Cassiopeiæ are examples of this class. The solar lines now steadily increase in intensity and the hydrogen lines diminish until the latter are no more intense than some of the solar lines. The typical second type stars are here reached and are represented by α Aurigæ, α Centauri, and α Ursæ Minoris. They are called G in the Draper catalogue or E if so faint that only the principal lines are visible. Before reaching this point we may have the hydrogen and solar systems of lines both strong, as in α Canis Minoris. It is, therefore, difficult to decide whether both substances are combined in a single star or whether the star is a close double, one component having a spectrum of the first, the other of the second type. This combination often occurs in double stars. In fact it has long been noticed that in the case of double stars, the brighter component is frequently of a reddish, the fainter of a bluish tint. The spectrum of the first star is then often of the second, while that of the second star is of the first type.

The photographs of the prismatic spectra so far described have a uniform density from the F to the H lines, that is from wave length 397 to 486. As we progress in the series the density of the portion of the spectrum of greater wave length increases as compared with the other portion. With sufficient dispersion the spectrum is seen to undergo a sudden diminution in density as the wave length diminishes at the point whose wave length is 430. The difference in brightness becomes more marked as the dispersion diminishes, so that when the dispersion is small very faint stars of this class may be recognized by their short spectra, the portion whose wave length is less than 430 not being visible. Probably the classification of spectra may be carried to fainter stars by means of this property than by any other. The letters H, I, and K are used in the Draper catalogue to designate such stars. Their spectra may be regarded as forming a second division of the second type. The sun and α Bootis are striking examples of this class, and α Tauri is a star still further advanced in the series. As we progress in the sequence, a second sudden change in intensity takes place at the point whose wave length is 476. Unlike the other change, the intensity of the portion of shorter wave length here exceeds that of greater wave length. This may be regarded as the distinctive feature of the photographic spectra of stars of the third type. The brightest star of this class is α Orionis. The letter M is used to designate spectra of the third type in the Draper catalogue. These stars may be further subdivided into four classes, of which the first is that just described. The second is represented by α Herculis, in which the spectrum is distinctly banded, each band having its edge of greater wave-length bright. The third class is not represented by any bright star. Many of the variable stars of long period have this spectrum when they are not near their maxima. Variable stars of long period, when near maxima, constitute the fourth division, which differs from the third only in having one or more of the hydrogen lines bright.

Two classes of spectra must now be considered which are not provided for in the above classification. The first of these consists of the spectra of gaseous nebulæ, the second that of the stars whose spectra consist mainly of bright lines. The wave lengths of the lines in both of these classes of spectra appear to coincide with those of the Orion and hydrogen lines. They therefore appear to precede the Orion stars in the sequence described above, but the lines are bright instead of dark. While an ordinary star may be regarded as having a bright nucleus giving a continuous spectrum surrounded by an absorbing medium, the bright nucleus in these objects is wanting, and the spectrum appears to be directly due to the incandescent gas. The reversal in brightness may thus be explained. The gaseous nebulæ can be divided into at least two classes and the bright line stars into at least three. A few other stars have one or more bright lines in their spectra; for instance, such stars as γ Cassiopeiæ and φ Persei, in which the F line is bright. They generally belong to the Orion class, and probably so much hydrogen is present in their atmospheres that the absorption is overbalanced by the direct light of the gases.

One other class of spectra remains, that of stars of the fourth type. Their spectra appear to be identical with that of carbon. Almost sixty of these objects are known. They are intensely red, and therefore difficult to study photographically. No connection has as yet been established between them and the sequence of spectra described above.

A few peculiar stars like Nova Aurigæ remain, but their number is so small that for the present each may be considered by itself.

The classification of the stars according to their spectra is so far reaching that it should be applied to each of their other properties. For instance, of the variable stars it appears that all known Algol stars have spectra of the first type, while long period variables in general are of the third type, and have the hydrogen lines bright when near their maxima, as stated above. This property has led to the discovery of more than twenty objects of this class, and no exception has been found of a star having this spectrum whose light does not really vary. Of the variables of long period which have been discovered visually, the hydrogen lines have been photographed as bright in forty-one, the greater portion of the others being too faint or too red to be studied with our present means. A few variable stars like U Hydræ, R. Sculptoris, and B.D. + 62° 596 are of the fourth type. Their variation is small and their red color renders their visual observation uncertain. Variable stars of short period generally have spectra of the second type, but some like β Lyræ present special peculiarities.

The motion of the sun in space, as derived from stars of each class of spectrum, is a problem of especial importance. The plan of the Henry Draper Memorial provides for the study of each of these and similar problems.

In general, it may be stated that with a few exceptions, all the stars may be arranged in a sequence, beginning with the planetary nebulæ, passing through the bright line stars to the Orion stars, thence to the first type stars and by insensible changes to the second and third type stars. The evidence that the same plan governs the construction of all parts of the visible universe is thus conclusive.

Harvard College Observatory, Cambridge, Mass., August 5, 1893.

* Read at the Congress of Astronomy and Astro-Physics, Chicago, August, 1893.

MANURING SUGAR BEETS.

THE manufacturers of sugar from sugar beet in Germany, at their recent congress, had before them the report of Dr. Hellriegel, of the Bernburg Agricultural Station, on the manurial requirements of the sugar beet. This report was published in the *Sucrerie Belge*, and contained an account of a number of interesting experiments, of which we have prepared the following summary:

Dr. Hellriegel, taking as his starting point the principle that the aim of the agricultural chemist is to determine for each plant the minimum quantity of each fertilizing material which is necessary for its normal vegetation, has made a series of experiments on sugar beets grown in a specially prepared soil, each beet being kept separate, and given as much soil as it would generally have when grown in a field, while the conditions of growth, moisture, etc., were kept as close as possible to those prevailing on the large scale. It was found in the sterilized soil employed that beets could not be grown, though they were free from disease of any kind. Healthy and normal beets, however, were obtained when a sufficiency of lime, magnesia and sulphuric acid was added to the soil, and also a mixture of 2·940 grammes of nitrate, 2·840 grains of phosphoric acid soluble in water, and 6·594 grammes of potash (as phosphate or chloride) per head of beet. The beetroots thus obtained developed normally, and attained a total weight of 813 grammes.

Experiments were then made diminishing gradually and successively the three last-named elements. Naturally the plants in time began to deteriorate, and it was found that the plants suffered quicker when the nitrogen was reduced than when potash and phosphoric acid were wanting; the falling off in the case of the two latter being about equal, while a lack of these ingredients causes the plants to be poor. An excess does not do much good either, the experiments recorded for each element showing that at a certain point, *about* midway between what was found to be an excess and what was too little, the most satisfactory results were obtained.

The deduction which follows from an examination of the tabulated results of the experiments is that, to obtain a normal beet of about 800 grammes weight, there are required:

2·9 grammes of nitrogen.
1·2 " phosphoric acid.
1·7 " potash.

It will be seen that these results differ much from what is actually done in practice, but it must be borne in mind that when manure is applied on a large scale, one does not have to supply *all* the fertilizing materials the plant requires, but only such ingredients as the soil is short of. Consequently, as soils are usually poorer in phosphoric acid than nitrogen and potash, it often happens that the addition of a phosphatic manure is found to produce excellent results. It may be added, however, that of late years the addition of phosphoric acid has been carried to excess in the oppo-

site direction, too much being added instead of too little. We now come to the individual action of each of these three principal fertilizing agents upon the beet.

When the nitrogen is diminished (or what amounts to the same thing, when the soil is deficient in available nitrogen), the yield and also the quantity of leaves is reduced, but the proportion of roots to leaves and the percentage of sugar is not altered.

If potash is wanting, there is also a diminution in the yield, but in less degree than with nitrogen. The quantity of leaves is not sensibly affected, but the roots suffer considerably in weight and percentage of sugar. These observations are accounted for because the first material formed in the plant is plasma, which is composed of a chemical compound containing much nitrogen. Without nitrogen, therefore, there could be no formation of the plant. If the plant has not enough nitrogen at its disposal, it uses it all up to form plasma cells and leaves, and then it is obliged, for want of nitrogen, to stop developing further. It does not die on that account, but the final result will be a small but otherwise normal plant, the root of which will be rich in sugar—the ideal of the manufacturer.

If, on the other hand, one places too much nitrogen at the disposal of the plant, it will most probably produce more plasma than can be properly utilized during the customary time of vegetation, and the result will be a beetroot rich in leaves and water, but not in sugar. If a very large excess of nitrogen is given, the plant will not be able to convert it into plasma and it will pass unchanged into the juice, and nitrous beets will be obtained.

The action of potash in the plant is but little known. A plant containing no potash would be able to germinate, but not develop, as it could not form any starch. If a beetroot is given an insufficient quantity of potash, but plenty of the other fertilizers, it will form plasma in abundance but no starch, which ought to be formed to assist in the development of the roots, etc., to be ultimately converted into sugar. This phenomenon has yet to be explained, as potash does not enter into the composition of starch, and yet none is formed unless the former is present in sufficient quantity. Should there be an excess of potash, however, little harm can be done, as it can pass into the juice and help to increase the percentage of salts obtained in the sugar manufacturing process.

The action of phosphoric acid is anything but clearly indicated by Dr. Hellriegel's experiments. It is undoubtedly necessary to the growth of the plant, but the investigator prefers to wait till he has made further experiments before he makes any definite statements.

From the experiments made it seems, therefore, that in order to obtain 100,000 beets per hectare, in normal condition, weighing about 800 grammes and containing say 14 per cent. of sugar, it is necessary for the soil to contain, in a state ready for assimilation:

Nitrogen	292 kilogrammes.
Phosphoric acid	120 "
Potash	172 "

which is equivalent to about the following quantities of suitable fertilizers:

Sodium nitrate	1,800 kilogrammes.
Superphosphate (20 per cent.)	600 "
Kainit	1,400 "

It is, however, evident at once that it would be absurd to give such large quantities of fertilizers to the soil, which, in all probability, contains a considerable quantity of the necessary ingredients. It therefore becomes necessary to estimate these quantities. It is true that the analysis of soils, apart from the estimation of lime, iron, and phosphoric acid, and the like, is in an unsatisfactory state, but this deficiency can in a large measure be overcome by analyzing the plants, and noticing what they are deficient in. From a number of experiments which have been made in the past, it would seem that a beetroot contains usually:

Nitrogen about	0·9 per cent.
Phosphoric acid about	0·3 "
Potash about	0·4 "

An instance of how an analysis of the beet can indicate how the crop can best be manured is shown in the following case, which occurred in actual practical farming. There are two crops in two different fields, giving a crop as follows:

	A	B
Yield of beets per hectare	30,000 kilos.	42,000 kilos.
Richness in sugar	17 per cent.	14 per cent.

An average of the analyses of the entire beetroot gave the following results:

	A	B
Nitrogen	0·8 per cent.	1·5 per cent.
Phosphoric acid	0·4 "	0·6 "
Potash	1·0 "	0·6 "

In the case of A, potash is the only element in excess of the needs of the plant, and consequently the percentage of sugar is according to the foregoing deductions high and the crop low. By adding to the soil a manure rich in nitrogen and phosphoric acid one might naturally hope to increase the yield without detracting from the quality of the beet. In the case of B (where the crop is large, but poor in sugar) there is evidently too much nitrogen and an insufficiency of potash and phosphoric acid. By adding these there is every reason to expect that the percentage of sugar would be augmented without reducing the yield of beets. However, in order to extend our knowledge and verify these observations, it is necessary that experiments should be prosecuted for some years yet, so that a fuller grasp of the subject can be obtained.—*Chem. Tr. Jour.*

A GREEN COLORING MATTER FROM ESERINE.

By Sen. S. J. Ferreira da Silva.

The author announced in 1890 that eserine was the only alkaloid of the benzenic ammoniacal group which after treatment with fuming nitric acid of specific gravity 1·4 and evaporation to dryness gave a green residue along its edges. He finds that this reaction is very suitable for the identification of very small quantities of eserine. He takes a minute fragment of eserine or of one of its salts, places it in a small capsule of porcelain, and dissolves it in one or two drops of fuming nitric acid. He thus obtains a light yellow solution, which, if heated in the water bath, turns first to a deep yellow and then to an orange. If it is evaporated to dryness while stirring with a glass rod, we remark in one or two minutes after complete desiccation a change of color to a pure green. The green coloring matter thus produced is soluble in water and still more readily in concentrated alcohol. Its green solutions are not fluorescent, and yield on evaporation the green coloring matter unaltered. The aqueous solution of the green matter, if examined with the spectroscope, is characterized by two absorption bands: one, the more distinct, situate in the red between λ 670 and λ 688; the other, broader, but having less sharply defined edges, occupies a part of the indigo and the violet, especially between λ 400 and λ 418. There is also a very faint band in the orange. The reaction shows 0·005 grm. of the alkaloid. The author proposes for the green compound the name of chloreserine.

CARBORUNDUM.

Mr. Acheson's description was read at the stated meeting of the Franklin Institute, June 21, and recites his early experiments, as far back as the year 1880, for the production of crystallized carbon in the electric furnace, which led to the formation of the carbide of silicon, to which he gave the name carborundum, under the supposition that he had formed a combination of carbon and aluminum, the mixture in the furnace originally consisting of carbon and corundum, for which, later, a mixture of carbon, silex and common salt was substituted. Salt was found to be beneficial in facilitating the fusion and in protecting the mass from oxidation. Experience has shown that a good proportion for the mixture is 20 parts of carbon, 25 parts of sand and 10 parts of salt, by weight. A core of carbon is used to connect the poles and is found unaltered after the operation, it being surrounded by the mixture, while it serves to conduct the current, and by its resistance to transform the electrical energy into heat energy. In later forms of the furnace four carbon electrodes are used at each end of a rectangular box, or trough, built of fire-brick, and 6 ft. long, 18 in. wide and 12 in. deep. The core is tubular and extends nearly the length of the box. An alternating, and not a direct, current is used. To produce 150 lb. per day of 24 hours requires an expenditure of 78 H. P. for a like period, amounting to 12 H. P. hours for each pound of carborundum produced. A furnace of the capacity and construction named requires from 7½ to 8 hours' time to complete the transformation of a portion of the charge into 50 lb. of carborundum, and three charges are worked in 24 hours.

The carborundum as removed from the furnace is a mass of crystals incrusting the core in comparatively loose radial aggregates, which are crushed in water and then digested with dilute sulphuric acid for seven days to remove iron and other impurities. It is found that the crystals are not acted upon by any of the acids, not even hydrofluoric acid, which may be used to remove any excess of silica, nor are they affected by a current of hot oxygen by which any excess of carbon is removed, but they are slightly acted on by the caustic alkalies and the carbonates of the alkalies, and are decomposed by fusion with carbonate of soda. Analysis of a sample well cleaned by the above indicated methods showed the composition to be: Silicon, 69·10; carbon, 30·20; with small quantities of alumina, iron and lime as impurities, the presence of which gives the color, for if pure carbon and pure silicon are used the crystals are white.

Mr. Acheson gives the results of several analyses by Dr. Mulhaeuser, the company's chemist. He found the specific gravity of some of the green crystals to be 3·22. Prof. J. W. Richards found the specific gravity as 3·123 for the green crystals, and that the blue crystals have a lower specific gravity.

A crystallographic examination has been made by Prof. B. W. Frazier, of Lehigh University, who finds that the crystals are rhombohedral, their disk shape being due to the predominance of the basal pinacoid. He says: "The observed forms consisted of numerous direct and inverse rhombohedra with the basal pinacoid, and in some crystals the prism of the first order. In some crystals the rhombohedral symmetry was evident, in others the direct and inverse rhombohedra of the same parameters were found on the same crystal, so as to impart to it an appearance of holohedral hexagonal symmetry. This holohedral habit was observed in bluish green and blue crystals, while in those yellowish green crystals which were examined in the goniometer the habit was rhombohedral."

The value for the length of the vertical axis, calculated from four good measurements, was found to be c= 1·2264. An examination in polarized light gave the interference figure of a uniaxial mineral, thus confirming the determination of hexagonal symmetry made by measurements with the goniometer. Mr. Acheson also directs attention to the fact that W. P. Schuetzenberger, in May, 1892, in a communication to the Academy of Sciences of France, described the manufacture of a new chemical compound of simple formula, the symbol being S C. This was three months after Mr. Nikola Tesla had exhibited an electric lamp containing carborundum (silicide of carbon), the composition of which was not, however, known at that time.

It would appear from Prof. Frazier's report on the crystallization that there is a great difference in the habit of the crystals made at different times and under different conditions, thus confirming my own conclusions. The crystals I had were all tabular and decidedly rhombic in habit, with the rhombohedral planes so small that I could not measure their inclination with any instruments at hand. It should have been more distinctly stated in the former article that the figures given were intended as mere sketches of the general appearance of the crystals, rather than as exact crystallographic drawings.

Mr Acheson states that the powder of carborundum has been successfully used in polishing diamonds, and he believes that in the form of a very fine powder it compares favorably in hardness and cutting qualities with diamond powder of equal fineness.—*Wm. P. Blake, Engineering and Mining Journal.*

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